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(54) **SAFETY POWER DISCONNECTION FOR POWER DISTRIBUTION OVER POWER CONDUCTORS
TO POWER CONSUMING DEVICES**

SICHERHEITSTROMABSCHALTUNG ZUR STROMVERTEILUNG ÜBER STROMLEITER AN
STROMVERBRAUCHSVORRICHTUNGEN

DÉCONNEXION ÉLECTRIQUE DE SÉCURITÉ POUR DISTRIBUTION D'ÉLECTRICITÉ SUR DES
CONDUCTEURS ÉLECTRIQUES CONDUISANT À DES DISPOSITIFS CONSOMMATEURS
D'ÉLECTRICITÉ

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(56) References cited:
WO-A1-2004/093283 WO-A1-2012/071367
WO-A1-2016/176314 US-A1- 2011 007 443
US-A1- 2015 077 130

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Description

BACKGROUND

[0001] The disclosure relates generally to distribution of power to one or more power consuming devices over power wiring, and more particularly to remote distribution of power to remote units in a power distribution system, which may include distributed communications systems (DCS) such as distributed antenna systems (DAS) for example, for operation of power consuming components of the remote units.

[0002] Wireless customers are increasingly demanding wireless communications services, such as cellular communications services and Wi-Fi services. Thus, small cells, and more recently Wi-Fi services, are being deployed indoors. At the same time, some wireless customers use their wireless communication devices in areas that are poorly serviced by conventional cellular networks, such as inside certain buildings or areas where there is little cellular coverage. One response to the intersection of these two concerns has been the use of distributed antenna systems (DASs). DASs include remote antenna units (RAUs) configured to receive and transmit communications signals to client devices within the antenna range of the RAUs. DASs can be particularly useful when deployed inside buildings or other indoor environments where the wireless communication devices may not otherwise be able to effectively receive radio frequency (RF) signals from a source.

[0003] In this regard, **FIG. 1** illustrates a wireless distributed communications system (WDCS) **100** that is configured to distribute communications services to remote coverage areas **102(1)-102(N)**, where 'N' is the number of remote coverage areas. The WDCS **100** in **FIG. 1** is provided in the form of a DAS **104**. The DAS **104** can be configured to support a variety of communications services that can include cellular communications services, wireless communications services, such as RF identification (RFID) tracking, Wireless Fidelity (Wi-Fi), local area network (LAN), and wireless LAN (WLAN), wireless solutions (Bluetooth, Wi-Fi Global Positioning System (GPS) signal-based, and others) for location-based services, and combinations thereof, as examples. The remote coverage areas **102(1)-102(N)** are created by and centered on RAUs **106(1)-106(N)** connected to a central unit **108** (e.g., a head-end controller, a central unit, or a head-end unit). The central unit **108** may be communicatively coupled to a source transceiver **110**, such as for example, a base transceiver station (BTS) or a baseband unit (BBU). In this regard, the central unit **108** receives downlink communications signals **112D** from the source transceiver **110** to be distributed to the RAUs **106(1)-106(N)**. The downlink communications signals **112D** can include data communications signals and/or communication signaling signals, as examples. The central unit **108** is configured with filtering circuits and/or other signal processing circuits that are configured to support a specific

number of communications services in a particular frequency bandwidth (i.e., frequency communications bands). The downlink communications signals **112D** are communicated by the central unit **108** over a communications link **114** over their frequency to the RAUs **106(1)-106(N)**.

[0004] With continuing reference to **FIG. 1**, the RAUs **106(1)-106(N)** are configured to receive the downlink communications signals **112D** from the central unit **108** over the communications link **114**. The downlink communications signals **112D** are configured to be distributed to the respective remote coverage areas **102(1)-102(N)** of the RAUs **106(1)-106(N)**. The RAUs **106(1)-106(N)** are also configured with filters and other signal processing circuits that are configured to support all or a subset of the specific communications services (i.e., frequency communications bands) supported by the central unit **108**. In a non-limiting example, the communications link **114** may be a wired communications link, a wireless communications link, or an optical fiber-based communications link. Each of the RAUs **106(1)-106(N)** may include an RF transmitter/receiver **116(1)-116(N)** and a respective antenna **118(1)-118(N)** operably connected to the RF transmitter/receiver **116(1)-116(N)** to wirelessly distribute the communications services to user equipment (UE) **120** within the respective remote coverage areas **102(1)-102(N)**. The RAUs **106(1)-106(N)** are also configured to receive uplink communications signals **112U** from the UE **120** in the respective remote coverage areas **102(1)-102(N)** to be distributed to the source transceiver **110**.

[0005] Because the RAUs **106(1)-106(N)** include components that require power to operate, such as the RF transmitter/receivers **116(1)-116(N)** for example, it is necessary to provide power to the RAUs **106(1)-106(N)**. In one example, each RAU **106(1)-106(N)** may receive power from a local power source. In another example, the RAUs **106(1)-106(N)** may be powered remotely from a remote power source(s). For example, the central unit **108** may include a power source **122** that is configured to remotely supply power over the communications links **114** to the RAUs **106(1)-106(N)**. For example, the communications links **114** may be cable that includes electrical conductors for carrying current (e.g., direct current (DC)) to the RAUs **106(1)-106(N)**. If the WDCS **100** is an optical fiber-based WDCS in which the communications links **114** include optical fibers, the communications links **114** may be a "hybrid" cable that includes optical fibers for carrying the downlink and uplink communications signals **112D**, **112U** and separate electrical conductors for carrying current to the RAUs **106(1)-106(N)**.

[0006] Some regulations, such as IEC 60950-21, may limit the amount of direct current (DC) that is remote delivered by the power source **122** over the communications links **114** to less than the amount needed to power the RAUs **106(1)-106(N)** during peak power consumption periods for safety reasons, such as in the event a human contacts the wire. One solution to remote power

distribution limitations is to employ multiple conductors and split current from the power source **122** over the multiple conductors, such that the current on any one electrical conductor is below the regulated limit. Another solution includes delivering remote power at a higher voltage so that a lower current can be distributed at the same power level. For example, assume that 300 Watts of power is to be supplied to a RAU **106(1)-106(N)** by the power source **122** through a communications link **114**. If the voltage of the power source **122** is 60 Volts (V), the current will be 5 Amperes (A) (i.e., 300 W / 60 V). However, if a 400 Volt power source **122** is used, then the current flowing through the wires will be 0.75 A. However, delivering high voltage through electrical conductors may be further regulated to prevent an undesired current from flowing through a human in the event that a human contacts the electrical conductor. Thus, these safety measures may require other protections, such as the use of protection conduits, which may make installations more difficult and add cost.

US 2011/007443 A1 relates to methods and systems for monitoring leakage current and detecting fault conditions in electrical systems. It discloses a power distribution system with the technical features in the preamble of claim 1.

SUMMARY

[0007] The invention is defined by the features of the independent claims. Preferred embodiments are defined in the dependent claims.

[0008] Additional features and advantages will be set forth in the detailed description which follows and, in part, will be readily apparent to those skilled in the art from the description or recognized by practicing the embodiments as described in the written description and claims hereof, as well as the appended drawings.

[0009] It is to be understood that both the foregoing general description and the following detailed description are merely exemplary and are intended to provide an overview or framework to understand the nature and character of the claims.

[0010] The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate one or more embodiment(s), and together with the description serve to explain principles and operation of the various embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is a schematic diagram of an exemplary wireless distributed communications system (DCS) in the form of a distributed antenna system (DAS);

FIG. 2 is a schematic diagram of an exemplary optical-fiber based DCS in the form of a DAS configured

to distribute communications signals between a central unit and a plurality of remote units, and that can include one or more power distribution systems configured to distribute power to a plurality of remote units and provide a safety power disconnect of the power source to remote units;

FIG. 3A is a partially schematic cut-away diagram of an exemplary building infrastructure in which a DCS in **FIG. 2** can be provided;

FIG. 3B is a more detailed schematic diagram of the DCS in **FIG. 3A**;

FIG. 4 is a schematic diagram illustrating a power distribution system included in the DCS in **FIGS. 2-3B**, wherein the power distribution system is configured to provide safety power disconnect of the power source to a remote unit in response to a measured current from the connected power source when the remote unit is decoupled from the power source during a testing phase;

FIG. 5 is a timing diagram illustrating an exemplary timing sequence of the controller circuit in the power distribution system in the DCS in **FIG. 4**;

FIG. 6 is a flowchart illustrating an exemplary process of the controller circuit in the power distribution system of the DCS in **FIG. 4** coupling the remote unit during a normal operation phase and instructing the remote unit to decouple from the power source during testing phases to then measure current from the power source during a testing phase, although the method itself is not covered by the scope of the claims.

FIG. 7 is a graph illustrating exemplary safe and unsafe regions of body current for a given current impulse time;

FIG. 8 is a schematic diagram illustrating the DCS in **FIG. 4** with the power distribution circuit configured to distribute power from a power source to a plurality of remote units to provide power for operation of the remote units, and provide a safety power disconnect of the power source to remote units in response to a measured current from the power source;

FIG. 9 is a schematic diagram illustrating an exemplary power distribution system that can be employed as the power distribution systems in the DCS in **FIG. 8**;

FIG. 10 is a schematic diagram illustrating additional exemplary detail of the controller circuit of the power distribution system in **FIG. 8**;

FIG. 11 is a diagram of another exemplary power distribution system that can be provided in the DCS in **FIGS. 2** and **3**, wherein the power distribution system is configured to provide safety power disconnect of the power source to a remote unit in response to a measured differential current from the connected power source when the remote unit is decoupled from the power source during a testing phase; and

FIG. 12 is a schematic diagram of a generalized representation of an exemplary controller that can be

included in any component in a DCS, including but not limited to the controller circuits in the power distribution systems for coupling a remote unit to a power source during a normal operation phase and instructing the remote unit to decouple from the power source during testing phases to then measure current from the power source during a testing phase, wherein an exemplary computer system is adapted to execute instructions from an exemplary computer readable link.

DETAILED DESCRIPTION

[0012] Embodiments of the disclosure relate to safety power disconnection for power distribution over power conductors to power consuming devices systems. As a non-limiting example, a such power distribution may be provided in a distributed communications systems (DCS). For example, the DCS may be a wireless DCS, such as a distributed antenna system (DAS) that is configured to distribute communications signals, including wireless communications signals, from a central unit to a plurality of remote units over physical communications media, to then be distributed from the remote units wirelessly to client devices in wireless communication range of a remote unit. In exemplary aspects disclosed herein, the DCS includes one or more power distribution systems each configured to remotely distribute power from a power source over current carrying electrical conductors ("power conductors") to remote units to provide power-to-power consuming components of the remote units for operation. For example, a power distribution system may be installed on each floor of a multi-floor building in which the DCS is installed to provide power to the remote units installed on a given floor. Each power distribution system includes a current measurement circuit configured to measure current delivered by the power source over the power conductors to remote units. Each power distribution system also includes a controller circuit configured to communicate over a management communications link to the remote units receiving power from the power distribution circuit. The remote unit is configured to be decoupled from the power conductors from its power consuming components thereby disconnecting the load of the remote unit from the power distribution system. The current measurement circuit then measures current flowing on the power conductors and provides a current measurement to the controller circuit. The controller circuit is configured to disconnect the power source from the power conductors for safety reasons in response to detection of a load based on detecting a current from the power source in excess of a threshold current level. For example, a person contacting the power conductors will present a load to the power source that will cause a current to flow from the power source over the power conductors. If another load is not contacting the power conductors, no current (or only a small amount current due to current leakages for example) should flow from the

power source over the power conductors. The controller circuit can be configured to wait a period of time and/or until a manual reset instruction is received, before connecting the power source from the power conductors and remote unit coupling its power consuming components to the power conductors to once again allow current to flow from the power source to the remote units serviced by the power distribution system.

[0013] Before discussing exemplary details of power distribution systems, including power distribution systems that can be included in a DCS for remotely distributing power to remote units and provide safety power disconnect of a power source to the remote units starting at **FIG. 4**, an exemplary power distribution system that can include remote power distribution is described in **FIGS. 2-3B**.

[0014] In this regard, **FIG. 2** is a schematic diagram of such an exemplary power distribution system **250**. In this example, the power distribution system **250** is provided in the form of a DCS **200**, which is a distributed antenna system (DAS) **202** in this example. Note that the power distribution circuit **250** is not limited to a DCS or being provided in a DCS. A DAS is a system that is configured to distribute communications signals, including wireless communications signals, from a central unit to a plurality of remote units over physical communications media, to then be distributed from the remote units wirelessly to client devices in wireless communication range of a remote unit. The DAS **202** in this example is an optical fiber-based DAS that is comprised of three (3) main components. One or more radio interface circuits provided in the form of radio interface modules (RIMs) **204(1)-204(T)** are provided in a central unit **206** to receive and process downlink electrical communications signals **208D(1)-208D(S)** prior to optical conversion into downlink optical communications signals. The downlink electrical communications signals **208D(1)-208D(S)** may be received from a base transceiver station (BTS) or baseband unit (BBU) as examples. The downlink electrical communications signals **208D(1)-208D(S)** may be analog signals or digital signals that can be sampled and processed as digital information. The RIMs **204(1)-204(T)** provide both downlink and uplink interfaces for signal processing. The notations "1-S" and "1-T" indicate that any number of the referenced component, 1-S and 1-T, respectively, may be provided.

[0015] With continuing reference to **FIG. 2**, the central unit **206** is configured to accept the plurality of RIMs **204(1)-204(T)** as modular components that can easily be installed and removed or replaced in a chassis. In one embodiment, the central unit **206** is configured to support up to twelve (12) RIMs **204(1)-204(12)**. Each RIM **204(1)-204(T)** can be designed to support a particular type of radio source or range of radio sources (i.e., frequencies) to provide flexibility in configuring the central unit **206** and the DAS **202** to support the desired radio sources. For example, one RIM **204** may be configured to support the Personal Communication Services (PCS) radio band.

Another RIM **204** may be configured to support the 700 MHz radio band. In this example, by inclusion of these RIMs **204**, the central unit **206** could be configured to support and distribute communications signals, including those for the communications services and communications bands described above as examples.

[0016] The RIMs **204(1)-204(T)** may be provided in the central unit **206** that support any frequencies desired, including but not limited to licensed US FCC and Industry Canada frequencies (824-849 MHz on uplink and 869-894 MHz on downlink), US FCC and Industry Canada frequencies (1850-1915 MHz on uplink and 1930-1995 MHz on downlink), US FCC and Industry Canada frequencies (1710-1755 MHz on uplink and 2110-2155 MHz on downlink), US FCC frequencies (698-716 MHz and 776-787 MHz on uplink and 728-746 MHz on downlink), EU R & TTE frequencies (880-915 MHz on uplink and 925-960 MHz on downlink), EU R & TTE frequencies (1710-1785 MHz on uplink and 1805-1880 MHz on downlink), EU R & TTE frequencies (1920-1980 MHz on uplink and 2110-2170 MHz on downlink), US FCC frequencies (806-824 MHz on uplink and 851-869 MHz on downlink), US FCC frequencies (896-901 MHz on uplink and 929-941 MHz on downlink), US FCC frequencies (793-805 MHz on uplink and 763-775 MHz on downlink), and US FCC frequencies (2495-2690 MHz on uplink and downlink).

[0017] With continuing reference to **FIG. 2**, the received downlink electrical communications signals **208D(1)-208D(S)** are provided to a plurality of optical interfaces provided in the form of optical interface modules (OIMs) **210(1)-210(W)** in this embodiment to convert the downlink electrical communications signals **208D(1)-208D(S)** ("downlink electrical communications signals **208D(1)-208D(S)**") into downlink optical communications signals **212D(1)-212D(S)**. The notation "1-W" indicates that any number of the referenced component 1-W may be provided. The OIMs **210** may include one or more optical interface components (OICs) that contain electrical-to-optical (E-O) converters **216(1)-216(W)** to convert the received downlink electrical communications signals **208D(1)-208D(S)** into the downlink optical communications signals **212D(1)-212D(S)**. The OIMs **210** support the radio bands that can be provided by the RIMs **204**, including the examples previously described above. The downlink optical communications signals **212D(1)-212D(S)** are communicated over a downlink optical fiber communications link **214D** to a plurality of remote units **218(1)-218(X)** provided in the form of remote antenna units in this example. The notation "1-X" indicates that any number of the referenced component 1-X may be provided. One or more of the downlink optical communications signals **212D(1)-212D(S)** can be distributed to each remote unit **218(1)-218(X)**. Thus, the distribution of the downlink optical communications signals **212D(1)-212D(S)** from the central unit **206** to the remote units **218(1)-218(X)** is in a point-to-multipoint configuration in this example.

[0018] With continuing reference to **FIG. 2**, the remote units **218(1)-218(X)** include optical-to-electrical (O-E) converters **220(1)-220(X)** configured to convert the one or more received downlink optical communications signals **212D(1)-212D(S)** back into the downlink electrical communications signals **208D(1)-208D(S)** to be wirelessly radiated through antennas **222(1)-222(X)** in the remote units **218(1)-218(X)** to user equipment (not shown) in the reception range of the antennas **222(1)-222(X)**. The OIMs **210** may also include O-E converters **224(1)-224(W)** to convert the received uplink optical communications signals **212U(1)-212U(X)** from the remote units **218(1)-218(X)** into the uplink electrical communications signals **226U(1)-226U(S)** as will be described in more detail below.

[0019] With continuing reference to **FIG. 2**, the remote units **218(1)-218(X)** are also configured to receive uplink electrical communications signals **228U(1)-228U(X)** received by the respective antennas **222(1)-222(X)** from client devices in wireless communication range of the remote units **218(1)-218(X)**. The uplink electrical communications signals **228U(1)-228U(S)** may be analog signals or digital signals that can be sampled and processed as digital information. The remote units **218(1)-218(X)** include E-O converters **229(1)-229(X)** to convert the received uplink electrical communications signals **228U(1)-228U(X)** into uplink optical communications signals **212U(1)-212U(X)**. The remote units **218(1)-218(X)** distribute the uplink optical communications signals **212U(1)-212U(X)** over an uplink optical fiber communication link **214U** to the OIMs **210(1)-210(W)** in the central unit **206**. The O-E converters **224(1)-224(W)** convert the received uplink optical communications signals **212U(1)-212U(X)** into uplink electrical communications signals **230U(1)-230U(X)**, which are processed by the RIMs **204(1)-204(T)** and provided as the uplink electrical communications signals **230U(1)-230U(X)** to a source transceiver such as a base transceiver station (BTS) or base-band unit (BBU).

[0020] Note that the downlink optical fiber communications link **214D** and the uplink optical fiber communications link **214U** coupled between the central unit **206** and the remote units **218(1)-218(X)** may be a common optical fiber communications link, wherein for example, wave division multiplexing (WDM) may be employed to carry the downlink optical communications signals **212D(1)-212D(S)** and the uplink optical communications signals **212U(1)-212U(X)** on the same optical fiber communications link. Alternatively, the downlink optical fiber communications link **214D** and the uplink optical fiber communications link **214U** coupled between the central unit **206** and the remote units **218(1)-218(X)** may be single, separate optical fiber communications link, wherein for example, wave division multiplexing (WDM) may be employed to carry the downlink optical communications signals **212D(1)-212D(S)** on one common downlink optical fiber and the uplink optical communications signals **212U(1)-212U(X)** carried on a separate, only uplink op-

tical fiber. Alternatively, the downlink optical fiber communications link **214D** and the uplink optical fiber communications link **214U** coupled between the central unit **206** and the remote units **218(1)-218(X)** may be separate optical fibers dedicated to and providing a separate communications link between the central unit **206** and each remote unit **218(1)-218(X)**.

[0021] The DCS **200** in **FIG. 2** can be provided in an indoor environment as illustrated in **FIG. 3A**. **FIG. 3A** is a partially schematic cut-away diagram of a building infrastructure **232** employing the DCS **200**. **FIG. 3B** is a schematic diagram of the DCS **200** installed according to the building infrastructure **232** in **FIG. 3A**.

[0022] With reference to **FIG. 3A**, the building infrastructure **232** in this embodiment includes a first (ground) floor **234(1)**, a second floor **234(2)**, and a Fth floor **234(F)**, where 'F' can represent any number of floors. The floors **234(1)-234(F)** are serviced by the central unit **206** to provide antenna coverage areas **236** in the building infrastructure **232**. The central unit **206** is communicatively coupled to a signal source **238**, such as a BTS or BBU, to receive the downlink electrical communications signals **208D(1)-208D(S)**. The central unit **206** is communicatively coupled to the remote units **218(1)-218(X)** to receive optical uplink communications signals **212U(1)-212U(X)** from the remote units **218(1)-218(X)** as previously described in **FIG. 2A**. The downlink and uplink optical communications signals **212D(1)-212D(S)**, **212U(1)-212U(X)** are distributed between the central unit **206** and the remote units **218(1)-218(X)** over a riser cable **240** in this example. The riser cable **240** may be routed through interconnect units (ICUs) **242(1)-242(F)** dedicated to each floor **234(1)-234(F)** for routing the downlink and uplink optical communications signals **212D(1)-212D(S)**, **212U(1)-212U(X)** to the remote units **218(1)-218(X)**. The ICUs **242(1)-242(F)** may also include respective power distribution circuits **244(1)-244(F)** that include power sources as part of the power distribution system **250**, wherein the power distribution circuits **244(1)-244(F)** are configured to distribute power remotely to the remote units **218(1)-218(X)** to provide power for operating the power consuming components in the remote units **218(1)-218(X)**. For example, array cables **245(1)-245(F)** may be provided and coupled between the ICUs **242(1)-242(F)** that contain both optical fibers to provide the respective downlink and uplink optical fiber communications media **214D(1)-214D(F)**, **214U(1)-214U(F)** and power conductors **246(1)-246(F)** (e.g., electrical wire) to carry current from the respective power distribution circuits **244(1)-244(F)** to the remote units **218(1)-218(X)**.

[0023] With reference to the DCS **200** shown in **FIG. 3B**, the central unit **206** may include a power supply circuit **252** to provide power to the RIMs **204(1)-204(T)**, the OIMs **210(1)-210(W)**, and radio distribution circuits (RDCs) **254**, **256**. The downlink electrical communications signals **208D(1)-208D(S)** and the uplink electrical communications signals **226U(1)-226U(S)** are routed from

between the RIMs **204(1)-204(T)** and the OIMs **210(1)-210(W)** through RDCs **254**, **256**. In one embodiment, the RDCs **254**, **256** can support sectorization in the DCS **200**, meaning that only certain downlink electrical communications signals **208D(1)-208D(S)** are routed to certain RIMs **204(1)-204(T)**. A power supply circuit **258** may also be provided to provide power to the OIMs **210(1)-210(W)**. An interface **260**, which may include web and network management system (NMS) interfaces, may also be provided to allow configuration and communication to the components of the central unit **206**. A microcontroller, microprocessor, or other control circuitry, called a head-end controller (HEC) **262** may be included in central unit **206** to provide control operations for the central unit **206** and the DCS **200**.

[0024] As discussed above in reference to **FIG. 3A** and with continuing reference to **FIG. 3B**, the power distribution circuits **244(1)-244(F)** may be provided in the DCS **200** to remotely supply power to the remote units **218(1)-218(X)** for operation. For example, the power distribution circuits **244(1)-244(F)** may be configured to supply direct current (DC) power due to relative short distances and as a safer option than distributing alternating current (AC) power. Further, distributing DC power may avoid the need to provide AC-DC conversion circuitry in the remote units **218(1)-218(X)** saving area and cost. Remotely distributing power to the remote units **218(1)-218(X)** may be desired if it is difficult or not possible to locally provide power to the remote units **218(1)-218(X)** in their installed locations. For example, the remote units **218(1)-218(X)** may be installed in ceilings or on walls of a building. Even if local power is available, the local power may not be capable of supplying enough power-to-power the number of remote units **218(1)-218(X)** desired. However, regulations may also limit the amount of DC that is remotely delivered by the power distribution circuits **244(1)-244(F)** over the power conductors **246(1)-246(F)** to less than the amount needed to power the remote units **218(1)-218(X)** during peak power consumption periods for safety reasons, such as in the event a human contacts the power conductors **246(1)-246(F)**. One solution to these remote power distribution limitations is to employ multiple power conductors **246(1)-246(F)** and split current from the power distribution circuits **244(1)-244(F)** over the multiple power conductors **246(1)-246(F)** as shown, such that the current on any one power conductor **246(1)-246(F)** is below the regulated limit. Another solution includes delivering remote power at a higher voltage so that a lower current can be distributed at the same power level. For example, assume that 300 Watts of power is to be supplied to a remote unit **218(1)-218(X)** by a power distribution circuit **244(1)-244(F)** through a respective power conductor **246(1)-246(F)**. If the voltage of the power distribution circuit **244(1)-244(F)** is 60 Volts (V), the current will be 5 Amperes (A) (i.e., 300 W / 60 V). However, if a 400 Volt is employed, then the current flowing through the wires will be 0.75 A. However, delivering high voltage through power conductors **246(1)-**

246(F) may be further regulated to prevent an undesired current from flowing through a human in the event that a human contacts the power conductor 246(1)-246(F). Thus, these safety measures may require other protections, such as the use of protection conduits for the array cables 245(1)-245(F), which may make installations of the DSC 200 more difficult and add cost.

[0025] In this regard, FIG. 4 is a schematic diagram illustrating a power distribution circuit 244 of the power distribution system 250 in the form of the DCS 200 in FIGS. 2-3B. The power distribution circuit 244 in FIG. 4 corresponds to any of the power distribution circuits 244(1)-244(F) in FIGS. 3A and 3B. The power distribution circuit 244 includes a power source 400 that is configured to supply power (i.e., current I_1) to be distributed over the power conductors 246+, 246- to a load 401 of the remote unit 218 to provide power to the remote unit 218 for operation of its consuming components. For example, the power source 400 may be a DC/DC power supply (e.g., 48V DC/350V DC) or AC/DC power supply (e.g., AC/350 V DC). The power source 400 may be included in the same housing or chassis as the power distribution circuit 244, or separate from the power distribution circuit 244. As will be discussed in more detail below, the power distribution circuit 244 illustrated in FIG. 4 is configured to provide safety power disconnect of the power source 400 from the power conductors 246+, 246- in response to a measured current I_2 from the connected power source 400 when the remote unit 218 is decoupled from the power source 400 during a testing phase. The power distribution circuit 244 includes a current measurement circuit 402 configured to measure the current I_2 delivered by the power source 400 to a distribution power output 403 coupled to the power conductors 246+, 246- as an indication of a safety condition as to whether an external load, such as a human, is in contact on the power conductors 246+, 246-. If another load is not contacting the power conductors 246+, 246-, this means no current or only a small amount of current, due to current leakages for example, should flow from the power source 400 to the power conductors 246+, 246-. However, if an external load 418, such as a person, is contacting the power conductors 246+, 246-, this load 418 will present a load to the power source 400 that will cause the current I_2 to flow from the power source 400 over the power conductors 246+, 246-. This current I_2 can be detected as a method of detecting an external load 418, such as a human, in contact with the power conductors 246+, 246- to cause the power distribution circuit 244 to decouple the power source 400 from the power conductors 246+, 246- as a safety measure.

[0026] In this regard, with reference to FIG. 4, the power distribution circuit 244 includes a controller circuit 404. The controller circuit 404 is configured to send a distribution power connection control signal 406 indicating a distribution power connection state to close a distribution switch circuit 408 to couple the power source 400 to the current measurement circuit 402. The closing of the dis-

tribution switch circuit 408 allows current I_1 to be drawn from the power source 400 and be carried by the power conductor 246+ to a remote power input 409 of the remote unit 218. To determine if an external load 418 other than the remote circuit 218, such as a human, is contacting the power conductors 246+, 246-, the controller circuit 404 could be configured to communicate over a management communications link 410 to the remote unit 218. The management communications link 410 may be electrical conductors (e.g. copper wire) or optical fiber medium as examples. The management communications link 410 may be a bidirectional communications link configured to carry a full duplex signal at a carrier frequency, such as 1.5 MHz for example. The controller circuit 404 is configured to send a remote power connection signal 412 indicating a remote power disconnect state to a switch control circuit 414 coupled to the management communications link 410. In response, the switch control circuit 414 is configured to send a remote power connection signal 411 indicating the remote power disconnect state to a remote switch input 413 to open a remote switch circuit 416 in the remote unit 218 to decouple the remote unit 218 from power conductor 246+ thereby disconnecting the load of the remote unit 218 from the power distribution circuit 244. This allows a measurement current on the power conductors 246+, 246- to be associated with an external load 418 and not the load of the remote unit 218. When the remote switch circuit 416 is open, power is provided to the load 401 from the capacitor C_1 . The current measurement circuit 402 measures the current on the power conductors 246+, 246- while the remote unit 218 is decoupled from the power source 400. If an external load 418 is not contacting the power conductors 246+, 246-, this means no current (or only a small amount of current due to current leakages for example) should flow from the power source 400 to the power conductors 246+, 246-. However, if an external load 418, such as a person, is contacting the power conductors 246+, 246-, this load 418 will present a load to the power source 400 that will cause current I_2 to flow from the power source 400 over the power conductors 246+, 246-. Any measured current I_2 by the current measurement circuit 402 is communicated to the controller circuit 404. In response to detection of the external load 418 as a function of the measured current I_2 exceeding a predefined threshold current level, the controller circuit 402 is configured to communicate the distribution power connection control signal 406 indicating a distribution power disconnect state to the distribution switch circuit 408 to disconnect the power source 400 from the power conductors 246+, 246- for safety reasons. This is because the external load 418 applied to the power conductors 246+, 246- to cause the current I_2 to flow from the power source 400 may be a human contacting the power conductors 246+, 246-.

[0027] Note that the management communications link 410 can be a separate communications link from the power conductors 246+, 246- or a modulated signal coupled to the power conductors 246+, 246- such that the remote

power connection signal **412** is modulated with power over the power conductors **246+**, **246-**. If the management communications link **410** is provided as a separate communications link, the management communications link **410** may be electrical conducting wire, such as copper wires for example. The management communications link **410** could also carry power to the switch control circuit **414** to power the switch control circuit **414** since the management communications link **410** is coupled to the switch control circuit **414**. For example, the predefined current threshold level may be based on the voltage of the power source **400** and an estimated 2,000 Ohms resistance of a human. For example, the International Electric Code (IEC) 60950-21 entitled "Remote Powering Regulatory Requirements" provides that for a 400 VDC maximum line-to-line voltage, the human body resistance from hand to hand is assumed to be 2,000 Ohms resulting in a body current of 200 mA. The remote unit **218** is eventually recoupled to the power source **400** to once again be operational.

[0028] After the controller circuit **404** communicates the distribution power connection control signal **406** indicating the distribution power disconnect state to the distribution switch circuit **408** to disconnect the power source **400** from the power conductors **246+**, **246-**, the controller circuit **404** can be configured to wait a period of time and/or until a manual reset instruction is received before recoupling the power source **400** to the remote unit **218**. In this regard, the controller circuit **404** can communicate the distribution power connection control signal **406** indicating a distribution power connect state to the distribution switch circuit **408** to cause the distribution switch circuit **408** to be closed to couple the power source **400** to the power conductors **246+**, **246-**. The controller circuit **404** can also send the remote power connection signal **412** indicating a remote power connect state to the switch control circuit **414** to generate the remote power connection signal **411** to cause the remote switch circuit **416** in the remote unit **218** to be closed to once again couple the remote unit **218** to the power conductor **246+** thereby connecting the load of the remote unit **218** to the power distribution circuit **244**. The capacitor **C₁** in the remote unit **218** is charged by the power source **400** when the remote unit **218** is coupled to the power conductors **246+**, **246-**. The energy stored in the capacitor **C₁** allows the remote unit **218** to continue to be powered during a testing phase when the remote switch circuit **416** is open. The period of time in which the remote switch circuit **416** is open is such that the discharge of the energy stored in the capacitor **C₁** is sufficient to power the remote unit **218**. A resistor **R₁** is coupled across the remote switch circuit **416** to allow multiple drops / remote units **218** to be connected to the same power input **409**. The overall equal parallel resistances can be a higher than the body / touch resistance of approximately 2 kOhms. The resistance **R₁** can be increased by reducing capacitance **C₁** to allow a faster charging time. Powering the switch control circuit **414** in the remote unit **218** from the manage-

ment communications link **410** could avoid the need or desire to include resistor **R₁** as the switch control circuit **414** would be capable of powering on faster and thus also synchronizing to the power distribution circuit **244(1)** faster. With continuing reference to **FIG. 4**, note that an optional current limiter circuit **420** can be provided in the remote unit **218** and coupled to the remote switch circuit **416**. The current limiter circuit **420** is configured to limit and avoid an inrush current, which may be identified by the power distribution circuit **244** as an overload. This can cause the controller circuit **404** in the power distribution circuit **244** to send a remote power connection signal **411** indicating the remote power disconnect state to a remote switch input **413** to open a remote switch circuit **416** in the remote unit **218** to decouple the remote unit **218** from power conductor **246+**, thereby disconnecting the load of the remote unit **218** from the power distribution circuit **244**. A DC/DC converter **421** in the remote unit **218** can convert a high voltage from the power source **400** (e.g., 400 V) to the required operation voltage of the load **401** (e.g. 48 V). A power line **423** can be provided on the output side of the DC/DC converter **421** to provide an operational voltage to the switch control circuit **414** for operation. An optional load switch circuit **425** can also be provided between the current limiter circuit **420** and the load **401** to connect and disconnect the load **401** from the power conductors **246+**. For example, the load switch circuit **425** may be under control of the switch control circuit **414**.

[0029] In an alternative embodiment, the load switch circuit **425** can be locally controlled by the switch control circuit **414** by a pulse width modulated (PWM) signal for example instead of being controlled by the remote power connection signal **412**. The PWM rate is set by the switch control circuit **414** to 0% initially. To switch control circuit **414** can gradually increase the PWM rate from 0% to 100% to control inrush current. This can also allow the current limiter circuit **420** to be eliminated, if desired, but elimination or presence is not required.

[0030] In this example in **FIG. 4**, a fast distribution power connection control signal **406** is employed that is implemented at a lower protocol level for the efficiency of the power transfer, as it allows shorter load disconnect time, as the power transfer is done during the load connecting time. A management signal that is implemented at higher protocol level is subjected to a relatively high delay variations. In on example, the power connection control signal **406** is implemented in the physical level only in order to optimize it to the minimum possible delay variation or jitter. An improved timing synchronization, between the controller circuit **404** and the load disconnect control may allow a shorter load disconnecting time needed for the controller circuit **404** to check for lower current detection. In case of high delay variation, the disconnect time should be larger in order to ensure additional margin in order to allow current measurement to be conducted when there is higher confidence that the load **401** is disconnected. **FIG. 5** is a timing diagram **500** illustrating an

exemplary timing sequence **502** of the controller circuit **404** in the power distribution circuit **244** in the DCS **200** in **FIG. 4** causing the power source **400** to be coupled to the remote unit **218** for normal operation, and causing the power source **400** to be decoupled from the remote unit **218** in a testing operation to detect the external load **418** in contact with the power conductors **246+**, **246-**. As shown in **FIG. 5**, the remote power connect state and remote power disconnect state of the remote switch circuit **416** as controlled by the controller circuit **404** is shown as "CLOSE" states starting at time T_0 , T_2 , T_4 , T_6 , etc. in normal operation phases and "OPEN" states starting at time T_1 , T_3 , T_5 , T_7 , etc. in testing phases. The period of time between times T_1 - T_2 , T_3 - T_4 , and T_5 - T_6 when the remote switch circuit **416** is open is controlled such that energy stored in the capacitor C_1 when the remote switch circuit **416** is closed is sufficient to power the remote unit **218** during the testing phases. The current measurement circuit **402** measures the current I_2 flowing through the power conductors **246+**, **246-** in **FIG. 4**. To avoid leakage, in one example, the capacitor C_1 can be charged with a low current when the remote switch circuit **416** is open, meaning off. Once capacitor C_1 is charged to a high enough voltage such that the switch control circuit **414** can identify the remote power connection signal **412**, and the remote switch circuit **416** can be turned on and off periodically as discussed above.

[0031] Between times T_1 - T_2 , T_3 - T_4 , and T_5 - T_6 , when the remote switch circuit **416** is open decoupling the remote unit **218** from the power conductors **246+**, **246-**, the controller circuit **404** detects no current flowing as an indication that the external load **418** is not contacting the power conductors **246+**, **246-**. However, as shown in **FIG. 5**, after time T_7 , the current measurement circuit **402** measures a current I_2 which is detected by the controller circuit **404**, which is indicative of the external load **418** being in contact with the power conductors **246+**, **246-**. If the controller circuit **404** detects the current I_2 exceeding the predefined threshold current level, this indicates the external load **418** being in contact with the power conductors **246+**, **246-**. The controller circuit **404** detects the current I_2 exceeding the predefined threshold current level shown at **504** in **FIG. 5** within the detection time **506**. In response, as shown in **FIG. 5**, the controller circuit **404** will communicate the distribution power connection control signal **406** indicating a distribution power disconnect state to the distribution switch circuit **408** to cause the distribution switch circuit **408** to be opened to decouple the power source **400** from the power conductors **246+**, **246-** for safety reasons.

[0032] Turning back to **FIG. 4**, the power distribution circuit **244** includes a positive distribution power input **422I(P)** configured to receive current distributed by the power source **400**. A negative distribution power input **422I(N)** provides a return path for the current. The power distribution circuit **244** also includes a distribution power output **422O** configured to distribute the received current over the power conductor **246+** coupled to the remote

unit **218**. The remote unit **218** coupled to the power distribution circuit **244** is deemed assigned to the power distribution circuit **244**. The distribution switch circuit **408** is coupled between the positive distribution power input **422I(P)** and the distribution power output **422O**. The distribution switch circuit **408** includes a distribution switch control input **424I** configured to receive the distribution power connection control signal **406** indicating the distribution power connection mode, which is either a distribution power connect state or a distribution power disconnect state. For example, the distribution power connection mode may be indicated by a bit in the distribution power connection control signal **406**, where a '1' bit is a distribution power connect state and a '0' bit is a distribution power disconnect state, or vice versa. The distribution switch circuit **408** is configured to be closed to couple the positive distribution power input **422I(P)** to the distribution power output **422O** in response to the distribution power connection mode of the distribution power connection control signal **406** indicating the distribution power connect state. The distribution switch circuit **408** is further configured to be opened to decouple the positive distribution power input **422I(P)** from the distribution power output **422O** in response to the distribution power connection mode of the distribution power connection control signal **406** indicating the distribution power disconnect state.

[0033] With continuing reference to **FIG. 4**, the current measurement circuit **402** of the power distribution circuit **244** is coupled to the distribution power output **422O**. The current measurement circuit **402** includes a current measurement output **426O**. The current measurement circuit **402** is configured to measure a current at (i.e., flowing to) the distribution power output **422O** and generate a current measurement **428** on the current measurement output **426O** based on the measured current at the distribution power output **422O**. The power distribution circuit **244** also includes a distribution management communications output **432O** coupled to the management communications link **410**, which is coupled to the assigned remote unit **218**. The controller circuit **404** includes a current measurement input **434I** communicatively coupled to current measurement output **426O** of the current measurement circuit **402**.

[0034] In an alternative embodiment, with reference to **FIG. 4**, the need to provide the management communications link **410** between the controller circuit **404** in the power distribution circuit **244** and the remote unit **218** to send the remote power connection signal **412** indicating a remote power disconnect state to a switch control circuit **414** in the remote unit **218** can be avoided if desired. For example, the remote unit **218** could be configured to cause the switch control circuit **414** (or the switch control circuit **414** itself could be configured to) periodically open the remote switch circuit **416** to decouple the remote unit **218** from power conductor **246+** thereby disconnecting the load of the remote unit **218** from the power distribution circuit **244**. The remote unit **218** and/or the switch control

circuit **414** can synchronize to the controller circuit **404** generating the distribution power connection control signal **406** to the distribution switch circuit **408** to disconnect the power source **400** from the power conductors **246+**, **246-**. For example, the switch control circuit **414** in the remote unit **218** can be configured to monitor changes in current I_1 on the power conductor **246+**. The current I_1 will drop each time the distribution switch circuit **408** disconnects the power source **400** from the power conductors **246+**, **246-**, thereby disconnecting the load of the remote unit **218** from the power distribution circuit **244**. For example, the controller circuit **404** can be configured to disconnect the remote unit **218** every 2 ms. The remote switch circuit **416** can synchronize to this periodic disconnection event in a short period of time. Thus, if the switch control circuit **414** does not see a current drop on power conductors **246+** within a predefined period of time when expected according to the expected periodic disconnect time according to the timing determined by synchronization process, the switch control circuit **414** can open the remote switch circuit **416** to decouple the remote unit **218** from power conductor **246+** thereby disconnecting the load of the remote unit **218** from the power distribution circuit **244**. The switch control circuit **414** can close the remote switch circuit **416** to recouple the remote unit **218** to the power conductor **246+** thereby connecting the load of the remote unit **218** from the power distribution circuit **244** based on the expected timing of when the power distribution circuit **244** will close the distribution switch circuit **408** according to the timing determined by synchronization process. The discussion of further operation of the power distribution circuit **244** and the remote unit **218** discussed above for measuring current on the power conductors **246+**, **246-** is also applicable for this embodiment.

[0035] In a second alternative embodiment, to avoid the need to provide a separate management communications link **410** between the controller circuit **404** in the power distribution circuit **244**, the controller circuit **404** could be configured to periodically drop the output voltage on the power conductor **246+** to a known voltage level (e.g., from 350 VDC to 300 VDC) before communicating the distribution power connection control signal **406** indicating a distribution power disconnect state to the distribution switch circuit **408** to cause the distribution switch circuit **408** to be opened to decouple the power source **400** from the power conductors **246+**, **246-**. The remote unit **218** and/or the switch control circuit **414** therein can be configured to monitor the voltage on the power conductor **246+** to identify this voltage drop as a remote power connection signal **412** indicating a remote power disconnect state. In response, the switch control circuit **414** can open the remote switch circuit **416** to decouple the remote unit **218** from the power conductor **246+** thereby disconnecting the load **401** of the remote unit **218** from the power distribution circuit **244**. The remote unit **218** and/or the switch control circuit **414** can wait a predefined period of time to close the remote switch

circuit **416** to recouple the remote unit **218** to the power conductor **246+** thereby connecting the load **401** of the remote unit **218** from the power distribution circuit **244** based on the expected timing of when the power distribution circuit **244** will close the distribution switch circuit **408** according to the timing determined by synchronization process. The discussion of further operation of the power distribution circuit **244** and the remote unit **218** discussed above for measuring current on the power conductors **246+**, **246-** is also applicable for this embodiment.

[0036] In a third alternative embodiment, the management communications link **410** between the controller circuit **404** in the power distribution circuit **244**, the controller circuit **404** could be configured to periodically drop the output voltage on the power conductor **246+** to a known voltage level (e.g., from 350 VDC to 300 VDC) before communicating the distribution power connection control signal **406** indicating a distribution power disconnect state to the distribution switch circuit **408** to cause the distribution switch circuit **408** to be opened to decouple the power source **400** from the power conductors **246+**, **246-**. The remote unit **218** and/or the switch control circuit **414** therein can be configured to monitor the voltage on the power conductor **246+** to identify this voltage drop as a remote power connection signal **412** indicating a remote power disconnect state. In response, the switch control circuit **414** can open the remote switch circuit **416** to decouple the remote unit **218** from the power conductor **246+** thereby disconnecting the load **401** of the remote unit **218** from the power distribution circuit **244**. The remote unit **218** and/or the switch control circuit **414** can wait a predefined period of time to close the remote switch circuit **416** to recouple the remote unit **218** to the power conductor **246+** thereby connecting the load **401** of the remote unit **218** from the power distribution circuit **244** based on the expected timing of when the power distribution circuit **244** will close the distribution switch circuit **408** according to the timing determined by synchronization process. The discussion of further operation of the power distribution circuit **244** and the remote unit **218** discussed above for measuring current on the power conductors **246+**, **246-** is also applicable for this embodiment.

[0037] As shown in the exemplary process **600** in FIG. 6 referencing the DCS **200** in FIG. 4 (process not covered as such by the scope of the invention as defined by the appended claims, but included in the description because of illustrative purposes), in one example option, the controller circuit **404** is configured to communicate the remote power connection signal **412** comprising a remote power connection mode indicating a remote power disconnect state over the distribution management communications output **4320** coupled to the assigned remote unit **218** to cause the remote switch circuit **416** to open and decouple the remote unit **218** from the power conductor **246+** carrying the current I_1 (block **602** in FIG. 6). The controller circuit **404** is also configured to measure

a current I_2 received from the power source **400** coupled to the power conductor **246+** (block **604** in **FIG. 6**). The controller circuit **404** is configured to determine if the measured current I_2 on the current measurement input **434I** exceeds a predefined threshold current level (block **606** in **FIG. 6**). In response to the measured current I_2 exceeding the predefined threshold current level indicating that the external load **418** is contacting the power conductor **246+** or **246-**, the controller circuit **404** is configured to communicate the distribution power connection control signal **406** comprising the distribution power connection mode indicating the distribution power disconnect state to the distribution switch control input **424I** to cause the distribution switch circuit **408** to open to decouple the power source **400** from the current measurement circuit **402** and the power conductor **246+** (block **608** in **FIG. 6**). For example, the predefined threshold current level may be less than or equal to 200 mA or less than or equal to 100 mA, as examples. If instead, the measured current I_2 of the power distribution circuit **244** does not exceed the predefined threshold current level, the controller circuit **404** is configured to communicate the distribution power connection control signal **406** to provide the the distribution power connection mode indicating the distribution power connect state to the distribution switch control input **424I**. This causes the distribution switch circuit **408** to close or continue to be closed and couple or continue to couple the power source **400** to the current measurement circuit **402** and the power conductor **246+** for providing power to the remote unit **218**.

[0038] With continuing reference to **FIG. 4**, the controller circuit **404** is also configured to communicate the remote power connection signal **412** comprising the remote power connection mode indicating the remote power disconnect state over the distribution management communications output **432O** before determining if the measured current I_2 on the current measurement input **434I** exceeds a predefined threshold current level. This causes the remote switch circuit **416** to open to decouple the remote unit **218** from the power conductors **246+** or **246-**. This is so that when it is desired to test to determine if the external load **418** is contacting the power conductors **246+** or **246-**, the remote unit **218** is decoupled from the power conductors **246+** or **246-** so that the load **401** of the remote unit **218** is not causing a current to be drawn from the power source **400**. In this manner, any measured current I_2 on the current measurement input **434I** is an indication of the external load **418** contacting the power conductors **246+** or **246-** and not the load **401** of the remote unit **218**. As previously discussed, the energy stored in the capacitor C_1 when the remote unit **218** is coupled to the power conductors **246+** or **246-** allows the remote unit **218** to continue to be powered during the testing phase when the remote switch circuit **416** is open.

[0039] With continuing reference to **FIG. 4**, after the testing phase, the controller circuit **404** after a predefined period of time is configured to communicate the remote

power connection signal **412** with a remote power connection mode indicating a remote power connect state over the distribution management communications output **432O** and over the management communications link **410**. This causes the remote switch circuit **416** to close so that the remote unit **218** is again coupled to the power conductor **246+** to receive power from the power distribution circuit **244**. The controller circuit **404** may be configured to communicate the remote power connection signal **412** with a remote power connection mode indicating a remote power connect state over the distribution management communications output **432O** after a predefined period of time has elapsed communicating the remote power connection signal **412** with a remote power connection mode indicating a remote power disconnect state. The controller circuit **404** may be configured to initially communicate the remote power connection signal **412** of the remote power connection mode indicating the remote power connect state before communicating the remote power connection signal **412** of the remote power connection mode indicating the remote power disconnect state, so that the remote unit **218** is initially powered by the power distribution circuit **244** before any testing phases begin. As previously discussed in reference to **FIG. 5**, the controller circuit **404** may be configured to repeatedly communicate the remote power connection signal **412** of the remote power connection mode indicating the remote power connect state during a normal operation phase, and then communicate the remote power connection signal **412** of the remote power connection mode indicating the remote power disconnect state during a testing phase to continuously detect the external load **418** contacting the power conductors **246+**, **246-**.

[0040] **FIG. 7** is a graph **700** illustrating exemplary safe and unsafe regions of body current for a given current impulse time. The graph **700** plots a body current in mA on the X-axis, and a time impulse exposure duration in ms on the Y-axis. The curve D_1 illustrates a dividing line between a safe region **702** and a danger region **704** for human contact to a current. The shorter the time impulse duration of the current, the safer a human can withstand a larger body current. For example, according to IEC 60947-1, a current of 200 mA that flows through a human body for less than 10 ms is regarded to be safe and thus plotted in the safe region **702**. Therefore, in one example, power distribution circuit **244** in **FIG. 4** is designed in such a way that the close period of the distribution switch circuit **408** plus the detection time **506** of current measurement circuit **402** (see **FIG. 5**) will be lower than 10 ms, assuming that the time between current detection and the disconnection of the power supply **400** from the power conductors **246+**, **246-** by distribution switch circuit **408** is negligible. This is because the current measurement circuit **402** measured the current from the connected power source **400** to detect the external load **418**, as opposed to detecting the external load **418** through indirect methods, such as through the discharge of stored energy in capacitor C_1 that is charged when a power source is con-

nected and discharges during a testing phase when the power source is disconnected. In the power distribution circuit **244** in **FIG. 4**, the power source **400** is not decoupled from the power conductors **246+**, **246-** during the testing phase when the current measuring circuit **402** is measuring current I_2 . As another example, the power distribution circuit **244** may be configured to detect a body in contact with the power conductors **246+**, **246-** and cause the distribution switch circuit **408** to be opened in response within approximately 10 ms or less at a 200 mA body current or less as shown in area **706** in graph **700**. The power distribution circuit **244** may be also configured to detect a body in contact with the power conductors **246+**, **246-** within approximately 20 ms or less at a 100 mA body current or less as shown in area **708** in graph **700**.

[0041] **FIG. 8** is a schematic diagram illustrating the power distribution system **250** in the exemplary form of the DCS **200** with the power distribution circuit **244** configured to distribute power to a plurality of remote units **218(1)-218(X)**. Common components between the DCS **200** and the power distribution system **250** in **FIG. 4** and **FIG. 8** are shown with common element numbers and will not be re-described. As shown in **FIG. 8**, a plurality of remote units **218(1)-218(X)** are provided. Each remote unit **218(1)-218(X)** includes a remote power input **409(1)-409(X)** coupled to the power conductors **246+(1)**, **246-(1)**, **246+(X)**, **246-(X)**, respectively, which are configured to be coupled to the power source **400** as previously described in **FIG. 4**. The power distribution circuit **244** includes a plurality of power outputs **800O(1)-800O(X)** each configured to provide power to a respective distribution switch circuit **408(1)-408(X)** and current measurement circuit **402(1)-402(X)**, which are assigned to different remote units **218(1)-218(X)**. The current measurement circuits **402(1)-402(X)** are each coupled to a respective distribution power output **403(1)-403(X)** coupled to respective power conductors **246+(1)**, **246-(1)**, **246+(X)**, **246-(X)**. Thus, the power distribution from the power distribution circuit **244** to the remote units **218(1)-218(X)** is in a point-to-multipoint configuration in this example. The power conductors **246+(1)**, **246-(1)**, **246+(X)**, **246-(X)** are also coupled to remote power inputs **409(1)-409(X)**. The remote units **218(1)-218(X)** may also have remote power outputs **802(1)-802(X)** that are configured to carry power from the respective power conductors **246+(1)**, **246-(1)**, **246+(X)**, **246-(X)** received on the remote power inputs **409(1)-409(X)** to an extended remote unit, such as extended remote unit **218E**.

[0042] Also, as shown in the DCS **200** in **FIG. 8**, the management communications links **410(1)-410(X)** to each of the remote units **218(1)-218(X)** are provided by the respective power conductors **246+(1)**, **246-(1)**, **246+(X)**, **246-(X)**. In this example, a plurality of controller circuits **404(1)-404(X)** are provided and dedicated to each distribution power output **403(1)-403(X)** to control power distribution for each pair of power conductors **246+(1)**, **246-(1)** - **246+(X)**, **246-(X)** through the distribu-

tion power outputs **403(1)-403(X)** to the remote units **218(1)-218(X)**. As will be discussed in more detail below, also in this example, a central management circuit **804** is provided that is configured to send multiplexed communications to each of the remote units **218(1)-218(X)** to send the remote power connection signal **412** indicating a remote power disconnect state over a respective management communications link **410(1)-410(X)** to decouple the respective remote unit **218(1)-218(X)** from the respective power conductor **246+(1)-246+(X)** thereby disconnecting the load of the remote unit **218(1)-218(X)** from the power distribution circuit **244** similar to previously described with regard to **FIG. 4**. Any measured current I_2 by the respective measurement circuit **402(1)-402(X)** is communicated to the respective controller circuit **404(1)-404(X)**, which is in turn communicated to the central management circuit **804**. In response to detection of the external load **418** as a function of the measured current I_2 exceeding a predefined threshold current level, the central management circuit **804** is configured to communicate the distribution power connection control signal **406(1)-406(X)** indicating a distribution power disconnect state to the respective distribution switch circuit **408(1)-408(X)** to disconnect the power source **400** from the respective power conductors **246+(1)-246+(X)**, **246-(1)**, **246-(X)** for safety reasons. Also, as shown in **FIG. 8**, an extended remote unit **218E** may be coupled to the remote unit **218(1)** and also configured to receive power from the power distribution circuit **244** via the remote unit **218(1)**.

[0043] **FIG. 9** is a schematic diagram illustrating an exemplary power distribution circuit **244** that can be employed as the DCS **200** in **FIG. 8**. As shown in **FIG. 9**, a separate positive side controller circuit **404P** and a negative side controller circuit **404N** are provided. This may provide a lower cost solution than providing a single controller circuit **404** like in **FIG. 4** to control power distribution to both the power conductors **246+**, **246-**. The positive side controller circuit **404P** controls the power distribution of power from the power source **400** provided to the positive distribution power input **422I(P)** to the power conductor **246+**. The negative side controller circuit **404N** controls power from the power source **400** provided to the negative distribution power input **422I(N)** to the power conductor **246-**. The previous discussion regarding the features and options of the controller circuit **404** above are applicable to the positive controller circuit **404P** and the negative controller circuit **404N**.

[0044] With continuing reference to **FIG. 9**, the negative controller circuit **404N** is configured to receive first and second current measurements **428N(A)**, **428N(B)** from first and second current measurement circuits **402N(A)**, **402N(B)**. The negative controller circuit **404N** is configured to communicate distribution power connection control signals **406N(A)**, **406N(B)** to first and second distribution switch circuits **408N(A)**, **408N(B)** to control the coupling and decoupling of the power source **400** to the power conductor **246-** as previously described. The

reason for providing the first and second current measurement circuits **402N(A)**, **402N(B)** and the first and second distribution switch circuits **408N(A)**, **408N(B)** is for redundancy in the event that one of the first and second current measurement circuits **402N(A)**, **402N(B)** and/or one of the first and second distribution switch circuits **408N(A)**, **408N(B)** fail.

[0045] Similarly, the positive controller circuit **404P** is configured to receive first and second current measurements **428P(A)**, **428P(B)** from first and second current measurement circuits **402P(A)**, **402P(B)**. The positive controller circuit **404S** is also configured to communicate distribution power connection control signals **406P(A)**, **406P(B)** to first and second distribution switch circuits **408P(A)**, **408P(B)** to control the coupling and decoupling of the power source **400** to the power conductor **246+** as previously described. The reason for providing the first and second current measurement circuits **402P(A)**, **402P(B)** and the first and second distribution switch circuits **408P(A)**, **408P(B)** is for redundancy in the event that one of the first and second current measurement circuits **402P(A)**, **402P(B)** and/or one of the first and second distribution switch circuits **408P(A)**, **408P(B)** fail. The power distribution system **250** may service multiple remote units **218(1)-218(X)** as illustrated in the DCS **200** in FIG. 8. A multiplexer circuit **900**, which may also be a combiner circuit, may also be provided as shown in FIG. 9 to multiplex or combine providing remote power connection signals **412** over the power conductors **246+**, **246-**, as previously described.

[0046] With continuing reference to FIG. 9, isolation control lines **902A**, **902B** are provided between the positive controller circuit **404P** and the negative controller circuit **404N**. The isolated control line **902A** is used to communicate an immediate alarm signal **904A** to both the positive controller circuit **404P** and the negative controller circuit **404N** when there is a need to transfer an immediate alarm signal **904A** to disconnect both the power conductor **246+**, **246-** due to fault detection, such as an unwanted overload alarm. Another isolation control line **902B** is provided between the positive controller circuit **404P** and the negative controller circuit **404N**. The isolated control line **902B** is used as a management link to carry a management signal **904B** from the central unit **206** to support management functionalities like setting new current threshold detection levels for example. Examples of current detection thresholds can include leakage or unwanted load detection and maximum load / overcurrent detection. Another example of management functionality is to command the power conductors **246+**, **246-** to be disconnected to prevent a specific load or user from receiving power.

[0047] FIG. 10 is a schematic diagram illustrating additional exemplary detail of additional safety measures that can be provided for the power distribution circuit **244** of the power distribution system **250** in FIG. 8. In this example, the controller circuit **404** is configured to periodically generate a watchdog signal **1000**. For example,

the controller circuit **404** may generate a watchdog signal **1000** every 1 ms. A watchdog controller **1002** is provided that is configured to receive the watchdog signal **1000** and provide a watchdog output signal **1004** in response.

5 The watchdog output signal **1004** is provided to a logic circuit **1006** that is configured to control the distribution power connection control signal **406**. The logic circuit **1006** is designed so that if the watchdog controller **1002** does not receive the watchdog signal **1000** within a specified period of time, this means that the controller circuit **404** may have failed or otherwise may not be operating properly. In response, the watchdog output signal **1004** will be generated to cause the logic circuit **1006** to provide distribution power connection control signal **406** in a distribution power disconnect state to cause the distribution switch circuit **408** to open and decouple the power supply **400** from the power distribution circuit **244**.

[0048] With continuing reference to FIG. 10, if a fault is detected (e.g., an unwanted overload) such that the power should be decoupled from the power conductors **246+**, **246-**, the distribution power connection control signal **406** indicating the distribution power connection mode indicating a power disconnection state is also provided to a status LED **1008**. An opto-coupler circuit **1010** is provided that is configured to detect the power disconnection state from the status LED **1008** and generate the isolation control signal **904** to the positive controller circuit **404P** and the negative controller circuit **404N**. This causes disconnection of power to both the power conductor **246+**, **246-** due to this fault detection.

[0049] FIG. 11 is a schematic diagram illustrating another exemplary, alternative power distribution circuit **244(1)** that is provided in power distribution system **250(1)** in the exemplary form of a DCS **200(1)** similar to the DCS **200** in FIGS. 2-3B. The power distribution circuit **244(1)** includes the power source **400** that is configured to supply power (i.e., current I_L) to be distributed over the power conductors **246+**, **246-** to a load **401** of the remote unit **218** to provide power to the remote unit **218** for operation of its consuming components like the power distribution circuit **244** in FIG. 4. Common components between the DCS **200** in FIG. 4 and the DCS **200(1)** in FIG. 11 are shown with common element numbers therein, and thus will not be re-described. Components shown in the DCS **200(1)** in FIG. 11 shown with a label of '(N)' operate like their counterpart element numbers without label of '(N)' in the DCS **200** in FIG. 4.

[0050] In the DCS **200(1)** in FIG. 11, the power source **400** is configured to provide a differential voltage, in the form of a positive voltage on power conductor **246+**, a negative voltage on power conductor **246-**, with a ground conductor **246G**. In this example, this allows an external load **418(1)** connected between power conductors **246+**, **246-**, an external load **418(2)** connected between power conductors **246+**, **246G**, an external load **418(3)** connected between power conductors **246-**, **246G** to be detected by the power distribution circuit **244(1)**. To detect an external load **418(3)** connected between power conductors

246-, **246G**, another second current measurement circuit **402(N)** is provided and coupled to the power conductor **246-**. When non-zero current I_3 is measured by current measurement circuit **402(N)**, when remote switch circuit **416** is open, the controller circuit **404** uses this as an indication that an external load **418(3)** is connected between power conductors **426-** and **426G** and directs the distribution switch circuit **408(N)** to be opened.

[0051] The controller circuit **404** may also be configured to compare the currents I_2 , I_3 measured by current measurement circuits **402**, **402(N)**. If the currents I_2 , I_3 are not substantially identical, the controller circuit **404** may conclude that current flows through an external load contacting between either power conductors **246+**, **246-** to the ground power conductor ground **426G**. In this instance, the controller circuit **404** may cause distribution switch circuits **408** and **408(N)** to both be opened to decouple the power source **400** from power conductors **246+**, **246-**.

[0052] Also as shown in **FIG. 11**, a distribution multiplexer circuit **1100** is provided in the power distribution system **250(1)**. A remote multiplexer circuit **1102** is provided in the remote unit **218**. For example, similar to previously discussed in **FIG. 8**, the distribution multiplexer circuit **1100** may allow a single controller circuit **404** (or central management circuit therein as provided in **FIG. 8**), to communicate the distribution power connection control signal **406** to a plurality of remote units **218** one at a time. The distribution multiplexer circuit **1100** multiplexes the remote unit **218**, the distribution power connection control signal **406** is sent. The multiplexing may be based on frequency-domain multiplexing (FDM) or time-domain multiplexing (TDM) as non-limiting examples. The remote multiplexer circuit **1102** can demultiplex the distribution power connection control signal **406** for instruction.

[0053] It may also be desired for example, to include a diode bridge circuit **1104** (e.g., a full bridge diode circuit) coupled to the power input **409** in the remote unit **218** (e.g., can be part of the remote multiplexer circuit **1102**) to in case the power distribution circuit **244(1)** identifies fault / or unwanted load, and the controller circuit **404** disconnects distribution switch circuits **408**. The diode bridge circuit **1104** can block any potential stored energy from discharging towards the power conductors **246+**, **246-**. Adding a diode bridge circuit **1104** can also make the power input **409** of the remote unit **218** indifferent (i.e., insensitive) to the polarity of the power conductors **246+**, **246-** such that the remote unit **218** can function even if there is a polarity reversal in the power conductors **246+**, **246-**. However a drawback may be that for high current transfer, there is a relatively high power loss in the diode bridge circuit **1104** (e.g., 5 A on 2 V requires 10W of heat dissipation).

[0054] Note that any of the referenced inputs herein can be provided as input ports or circuits, any of the referenced outputs herein can be provided as output ports or circuits.

[0055] **FIG. 12** is a schematic diagram representation of additional detail illustrating a computer system **1200** that could be employed in any component in the DCS **200**, including but not limited to the controller circuits **404** in the power distribution systems **250**, **250(1)** for coupling a remote unit **218** to the power source **400** during a normal operation phase and instructing the remote unit **218** to decouple from the power source **400** during testing phases to then measure current from the power source **400** during a testing phase, including but not limited to the DCS **200** in **FIGS. 4**, **8** and **11** and the controller circuits **404**, **404M**, **404S** in **FIGS. 4** and **8-11**. In this regard, the computer system **1200** is adapted to execute instructions from an exemplary computer-readable medium to perform these and/or any of the functions or processing described herein.

[0056] In this regard, the computer system **1200** in **FIG. 12** may include a set of instructions that may be executed to program and configure programmable digital signal processing circuits in a DCS for supporting scaling of supported communications services. The computer system **1200** may be connected (e.g., networked) to other machines in a LAN, an intranet, an extranet, or the Internet. While only a single device is illustrated, the term "device" shall also be taken to include any collection of devices that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein. The computer system **1200** may be a circuit or circuits included in an electronic board card, such as, a printed circuit board (PCB), a server, a personal computer, a desktop computer, a laptop computer, a personal digital assistant (PDA), a computing pad, a mobile device, or any other device, and may represent, for example, a server or a user's computer.

[0057] The exemplary computer system **1200** in this embodiment includes a processing device or processor **1202**, a main memory **1204** (e.g., read-only memory (ROM), flash memory, dynamic random access memory (DRAM), such as synchronous DRAM (SDRAM), etc.), and a static memory **1206** (e.g., flash memory, static random access memory (SRAM), etc.), which may communicate with each other via a data bus **1208**. Alternatively, the processor **1202** may be connected to the main memory **1204** and/or static memory **1206** directly or via some other connectivity means. The processor **1202** may be a controller, and the main memory **1204** or static memory **1206** may be any type of memory.

[0058] The processor **1202** represents one or more general-purpose processing devices, such as a microprocessor, central processing unit, or the like. More particularly, the processor **1202** may be a complex instruction set computing (CISC) microprocessor, a reduced instruction set computing (RISC) microprocessor, a very long instruction word (VLIW) microprocessor, a processor implementing other instruction sets, or other processors implementing a combination of instruction sets. The processor **1202** is configured to execute processing logic

in instructions for performing the operations and steps discussed herein.

[0059] The computer system **1200** may further include a network interface device **1210**. The computer system **1200** also may or may not include an input **1212**, configured to receive input and selections to be communicated to the computer system **1200** when executing instructions. The computer system **1200** also may or may not include an output **1214**, including but not limited to a display, a video display unit (e.g., a liquid crystal display (LCD) or a cathode ray tube (CRT)), an alphanumeric input device (e.g., a keyboard), and/or a cursor control device (e.g., a mouse).

[0060] The computer system **1200** may or may not include a data storage device that includes instructions **1216** stored in a computer-readable medium **1218**. The instructions **1216** may also reside, completely or at least partially, within the main memory **1204** and/or within the processor **1202** during execution thereof by the computer system **1200**, the main memory **1204** and the processor **1202** also constituting computer-readable medium. The instructions **1216** may further be transmitted or received over a network **1220** via the network interface device **1210**.

[0061] While the computer-readable medium **1218** is shown in an exemplary embodiment to be a single medium, the term "computer-readable medium" should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The term "computer-readable medium" shall also be taken to include any medium that is capable of storing, encoding, or carrying a set of instructions for execution by the processing device and that cause the processing device to perform any one or more of the methodologies of the embodiments disclosed herein. The term "computer-readable medium" shall accordingly be taken to include, but not be limited to, solid-state memories, optical medium, and magnetic medium.

[0062] The embodiments disclosed herein include various steps. The steps of the embodiments disclosed herein may be formed by hardware components or may be embodied in machine-executable instructions, which may be used to cause a general-purpose or special-purpose processor programmed with the instructions to perform the steps. Alternatively, the steps may be performed by a combination of hardware and software.

[0063] The embodiments disclosed herein may be provided as a computer program product, or software, that may include a machine-readable medium (or computer-readable medium) having stored thereon instructions, which may be used to program a computer system (or other electronic devices) to perform a process according to the embodiments disclosed herein. A machine-readable medium includes any mechanism for storing or transmitting information in a form readable by a machine (e.g., a computer). For example, a machine-readable medium includes: a machine-readable storage medium

(e.g., ROM, random access memory ("RAM"), a magnetic disk storage medium, an optical storage medium, flash memory devices, etc.); and the like.

[0064] Unless specifically stated otherwise and as apparent from the previous discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing," "computing," "determining," or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data and memories represented as physical (electronic) quantities within the computer system's registers into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission, or display devices.

[0065] The algorithms presented herein are not inherently related to any particular computer or other apparatus. Various systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatuses to perform the required method steps. The required structure for a variety of these systems will appear from the description above. In addition, the embodiments described herein are not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the embodiments as described herein.

[0066] Those of skill in the art will further appreciate that the various illustrative logical blocks, modules, circuits, and algorithms described in connection with the embodiments disclosed herein may be implemented as electronic hardware, instructions stored in memory or in another computer-readable medium and executed by a processor or other processing device, or combinations of both. The components of the distributed antenna systems described herein may be employed in any circuit, hardware component, integrated circuit (IC), or IC chip, as examples. Memory disclosed herein may be any type and size of memory and may be configured to store any type of information desired. To clearly illustrate this interchangeability, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. How such functionality is implemented depends on the particular application, design choices, and/or design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but always within the scope of the invention as defined by the appended claims.

[0067] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a processor, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination

thereof designed to perform the functions described herein. Furthermore, a controller may be a processor. A processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration).

[0068] The embodiments disclosed herein may be embodied in hardware and in instructions that are stored in hardware, and may reside, for example, in RAM, flash memory, ROM, Electrically Programmable ROM (EPROM), Electrically Erasable Programmable ROM (EEPROM), registers, a hard disk, a removable disk, a CD-ROM, or any other form of computer-readable medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a remote station. In the alternative, the processor and the storage medium may reside as discrete components in a remote station, base station, or server.

[0069] It is also noted that the operational steps described in any of the exemplary embodiments herein are described to provide examples and discussion. The operations described may be performed in numerous different sequences other than the illustrated sequences if the resulting sequences of steps do not deviate from the scope of the invention as defined by appended claims. Furthermore, operations described in a single operational step may actually be performed in a number of different steps, provided that this does not result in subject-matter not falling within the scope of the invention as defined by the appended claims. Additionally, one or more operational steps discussed in the exemplary embodiments may be combined. Those of skill in the art will also understand that information and signals may be represented using any of a variety of technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips, that may be references throughout the above description, may be represented by voltages, currents, electromagnetic waves, magnetic fields, or particles, optical fields or particles, or any combination thereof.

[0070] Unless otherwise expressly stated, it is in no way intended that any method set forth herein be construed as requiring that its steps be performed in a specific order. Accordingly, where a method claim does not actually recite an order to be followed by its steps, or it is not otherwise specifically stated in the claims or descriptions that the steps are to be limited to a specific order, it is in no way intended that any particular order be inferred, provided that the resulting method does not extend beyond the scope of the invention as defined by

the appended claims.

[0071] It will be apparent to those skilled in the art that various modifications and variations can be made without departing from the spirit or scope of the invention. Since modifications, combinations, sub-combinations and variations of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims.

Claims

1. A power distribution system comprising:

one or more power distribution circuits (244) each comprising:

a distribution power input (422I) configured to receive current distributed by a power source (400);

a distribution power output configured to distribute the received current over a power conductor (246) coupled to an assigned remote unit (218) among a plurality of remote units (218);

a distribution switch circuit (408) coupled between the distribution power input (422I) and the distribution power output, the distribution switch circuit (408) comprising a distribution switch control input (424I) configured to receive a distribution power connection control signal (406) indicating a distribution power connection mode; the distribution switch circuit (408) configured to be closed to couple the distribution power input (422I) to the distribution power output in response to the distribution power connection mode indicating a distribution power connect state; and the distribution switch circuit (408) further configured to be opened to decouple the distribution power input (422I) from the distribution power output in response to the distribution power connection mode indicating a distribution power disconnect state; and

a current measurement circuit (402) coupled to the distribution power output and comprising a current measurement output (426O);

the current measurement circuit (402) configured to measure a current at the distribution power output and generate a current measurement on the current measurement output (426O) based on the measured current at the distribution power output;

a controller circuit (404) comprising:

one or more current measurement inputs (434I) communicatively coupled to the one or more current measurement outputs (426O) of the one or more current measurement circuits (402) of the one or more power distribution circuits (244); and
the controller circuit (404) configured to, for a power distribution circuit (244) among the one or more power distribution circuits (244):

generate the distribution power connection control signal (406) indicating the distribution power connection mode to the distribution switch control input (424I) of the power distribution circuit (244) indicating the distribution power connect state;
determine if the measured current on a current measurement input (434I) among the one or more current measurement inputs (434I) of the power distribution circuit (244) exceeds a predefined threshold current level when the distribution switch circuit (408) is closed to couple the distribution power input (422I) to the distribution power output; and
in response to the measured current of the power distribution circuit (244) exceeding the predefined threshold current level, communicate the distribution power connection control signal (406) indicating the distribution power connection mode to the distribution switch control input (424I) of the power distribution circuit (244) indicating the distribution power disconnect state, and

a housing containing the controller circuit (404), the current measurement circuit (402), and the power source (44), **characterized in that** the controller circuit (404) is further configured to:

lower a voltage level on the distribution power output (403: 422O) from a first voltage level to second voltage level distributing the received current over the power conductor (246) coupled to the assigned remote unit (218);
raise the voltage level on the distribution power output (403: 422O) from the second voltage level to the first voltage level distributing the received current over the power conductor (246) coupled to the assigned re-

mote unit (218);

determine if the measured current on the current measurement input (434I) among the one or more current measurement inputs (434I) of the power distribution circuit (244) exceeds the predefined threshold current level when the distribution switch circuit (408) is closed to couple the distribution power input (422I) to the distribution power output (403: 422O) in response to the raising of the voltage level on the power distribution output.

2. The power distribution system of claim 1, wherein:

the one or more power distribution circuits (244) each further comprise:

a distribution management communications output (432O) coupled to a management communications link (410) coupled to the assigned remote unit (218) among the plurality of remote units (218); and

the controller circuit (404) is further configured to, for a power distribution circuit (244) among the one or more power distribution circuits (244): communicate a remote power connection signal (412) comprising a remote power connection mode indicating a remote power disconnect state over the distribution management communications output (432O) coupled to the assigned remote unit (218) to the power distribution circuit (244) to cause the assigned remote unit (218) to decouple current from the power conductor (246) of the power distribution circuit (244).

3. The power distribution system of claim 2, in response to the measured current of the power distribution circuit (244) not exceeding the predefined threshold current level, communicate the distribution power connection control signal (406) comprising the distribution power connection mode to the distribution switch control input (424I) of the power distribution circuit (244) indicating the distribution power connect state.

4. The power distribution system of claim 2, wherein the controller circuit (404) is further configured to, for the power distribution circuit (244) among the one or more power distribution circuits (244), communicate the remote power connection signal (412) comprising the remote power connection mode indicating the remote power disconnect state over the distribution management communications output (432O) before determining if the measured current on a current measurement input (434I) among the one or more current measurement inputs (434I) of the power distribution circuit (244) exceeds the predefined threshold current level.

5. The power distribution system of claim 2, wherein the controller circuit (404) is further configured to, for the power distribution circuit (244) among the one or more power distribution circuits (244):
communicate the remote power connection signal (412) comprising the remote power connection mode indicating a remote power connect state over the distribution management communications output (432O) coupled to the assigned remote unit (218) to the power distribution circuit (244) to cause the assigned remote unit (218) to couple to a power conductor (246) of the power distribution circuit (244). 5
6. The power distribution system of claim 5, wherein the controller circuit (404) is configured to, for the power distribution circuit (244) among the one or more power distribution circuits (244):
communicate the remote power connection signal (412) comprising the remote power connection mode indicating the remote power connect state after a predefined time has elapsed after communicating the remote power connection signal (412) comprising the remote power connection mode indicating the remote power disconnect state. 10
7. The power distribution system of claim 5, wherein the controller circuit (404) is configured to, for the power distribution circuit (244) among the one or more power distribution circuits (244):
communicate the remote power connection signal (412) comprising the remote power connection mode indicating the remote power connect state before communicating the remote power connection signal (412) comprising the remote power connection mode indicating the remote power disconnect state. 15
8. The power distribution system of claim 6, wherein the controller circuit (404) is configured to, for the power distribution circuit (244) among the one or more power distribution circuits (244), repeatedly:
communicate the remote power connection signal (412) comprising the remote power connection mode indicating the remote power disconnect state over the distribution management communications output (432O); and
communicate the remote power connection signal (412) comprising the remote power connection mode indicating the remote power connect state over the distribution management communications output (432O) after the predefined time has elapsed after communicating the remote power connection signal (412) comprising the remote power connection mode indicating the remote power disconnect state. 20
9. The power distribution system of claim 1, wherein 25

for each power distribution circuit (244) among the one or more power distribution circuits (244):

the distribution power output (403: 422O) comprises the distribution management communications output (432O); and
further comprising a multiplexing circuit coupled between the distribution switch circuit (408) and the distribution power output (403: 422O);
the multiplexing circuit configured to multiplex the distribution power connection control signal (406) and the remote power connection signal (412) over the distribution power output (403: 422O) to the assigned remote unit (218). 30

10. The power distribution system of claim 2, wherein for each power distribution circuit (244) among the one or more power distribution circuits (244): 35

the distribution power output (403: 422O) comprises the distribution management communications output (432O); and
further comprising a combining circuit coupled between the distribution switch circuit (408) and the distribution power output (403: 422O);
the combining circuit configured to combine the distribution power connection control signal (406) and the remote power connection signal (412) over the distribution power output (403: 422O) to the assigned remote unit (218). 40

11. The power distribution system of claim 1, wherein: 45

each power distribution circuit (244) of the one or more power distribution circuits (244) further comprises:
a second current measurement circuit (402) coupled to the current measurement circuit (402), and comprising a second current measurement output (426O);
the second current measurement circuit (402) configured to measure the current at the distribution power output (403: 422O) and generate a second current measurement (428) on the second current measurement output (426O) based on the measured current at the distribution power output (403: 422O);
the controller circuit (404) further comprising: 50

one or more second current measurement inputs (434I) communicatively coupled to the one or more second current measurement outputs (426O) of the one or more second current measurement circuits (402) of the one or more power distribution circuits (244); and
the controller circuit (404) further configured to, for a power distribution circuit (244) 55

among the one or more power distribution circuits (244):

determine if the measured current on a second current measurement input (434I) among the one or more second current measurement inputs (434I) of the power distribution circuit (244) exceeds the predefined threshold current level; and
in response to the second measured current of the power distribution circuit (244) exceeding the predefined threshold current level, communicate the distribution power connection control signal (406) comprising the distribution power connection mode to the distribution switch control input (424I) of the power distribution circuit (244) indicating the distribution power disconnect state.

12. The power distribution system of claim 1, wherein:

each power distribution circuit (244) of the one or more power distribution circuits (244) further comprises:
a second current measurement circuit (402) coupled to the current measurement circuit (402), and comprising a second current measurement output (426O);
the second current measurement circuit (402) configured to measure the current at the distribution power output (403: 422O) and generate a second current measurement (428) on the second current measurement output (426O) based on the measured current received on the distribution power output (403: 422O);
the controller circuit (404) further comprising:

one or more second current measurement inputs (434I) communicatively coupled to the one or more second current measurement outputs (426O) of the one or more second current measurement circuits (402) of the one or more power distribution circuits (244); and
the controller circuit (404) further configured to, for a power distribution circuit (244) among the one or more power distribution circuits (244):

determine if the measured current on a second current measurement input (434I) among the one or more second current measurement inputs (434I) of the power distribution circuit (244) exceeds the predefined threshold current

level; and

in response to the second measured current of the power distribution circuit (244) exceeding the predefined threshold current level, communicate the distribution power connection control signal (406) comprising the distribution power connection mode to the distribution switch control input (424I) of the power distribution circuit (244) indicating the distribution power disconnect state.

13. The power distribution system of claim 1, wherein:

each power distribution circuit (244) of the one or more power distribution circuits (244) further comprises:

a second current measurement circuit (402) comprising a second current measurement output (426O);
the second current measurement circuit (402) configured to measure the current at a second distribution power output (403: 422O) and generate a second current measurement (428) on the second current measurement output (426O) based on the measured current received on the second distribution power output (403: 422O);

the controller circuit (404) further comprising:

one or more second current measurement inputs (434I) communicatively coupled to the one or more second current measurement outputs (426O) of the one or more second current measurement circuits (402) of the one or more power distribution circuits (244); and
the controller circuit (404) further configured to, for a power distribution circuit (244) among the one or more power distribution circuits (244):

determine a differential measured current between the measured current on the current measurement input (434I) and the second measured current on the second current measurement input (434I);
determine if the differential measured current exceeds the predefined threshold current level; and
in response to the differential measured current of the power distribution circuit (244) exceeding the predefined threshold current level, communicate the dis-

tribution power connection control signal (406) comprising the distribution power connection mode to the distribution switch control input (424I) of the power distribution circuit (244) indicating the distribution power disconnect state.

14. The power distribution system of claim 1, wherein the controller circuit (404) is further configured to periodically generate a watchdog signal; and further comprising a watchdog controller configured to:

receive the watchdog signal;
in response to not receiving the watchdog signal within a predefined time period, cause the distribution power connection control signal (406) (406) to indicate the distribution power disconnect state.

Patentansprüche

1. Stromverteilungssystem, umfassend:
eine oder mehrere Stromverteilungsschaltungen (244), jeweils umfassend:

einen Verteilungsstromeingang (422I), der konfiguriert ist, um Stromstärke zu empfangen, die von einer Stromquelle (400) verteilt wird;
einen Verteilungsstromausgang, der konfiguriert ist, um die empfangene Stromstärke über einen Stromleiter (246), der mit einer zugewiesenen entfernten Einheit (218) gekoppelt ist, auf eine Vielzahl von entfernten Einheiten (218) zu verteilen;
einen Verteilungsschaltkreis (408), der zwischen dem Verteilungsstromeingang (422I) und dem Verteilungsstromausgang gekoppelt ist, wobei der Verteilungsschaltkreis (408) einen Verteilungsschaltsteuereingang (424I) umfasst, der konfiguriert ist, um ein Verteilungsstromverbindungssteuersignal (406) zu empfangen, das einen Verteilungsstromverbindungsmodus angibt;
wobei der Verteilungsschaltkreis (408) konfiguriert ist, um geschlossen zu werden, um den Verteilungsstromeingang (422I) mit dem Verteilungsstromausgang zu koppeln, als Reaktion darauf, dass der Verteilungsstromverbindungsmodus einen Verteilungsstromverbindungsmodus angibt; und
der Verteilungsschaltkreis (408) ferner konfiguriert ist, um geöffnet zu werden, um den Verteilungsstromeingang (422I) als Reaktion darauf, dass der Verteilungsstromverbindungsmodus einen Verteilungsstromunterbrechungszustand

angibt, von dem Verteilungsstromausgang zu entkoppeln; und

eine Stromstärkemessschaltung (402), die mit dem Verteilungsstromausgang gekoppelt ist und einen Stromstärkemessausgang (426O) umfasst;

wobei die Stromstärkemessschaltung (402) konfiguriert ist, um eine Stromstärke an dem Verteilungsstromausgang zu messen und basierend auf der gemessenen Stromstärke an dem Verteilungsstromausgang eine Stromstärkemessung an dem Stromstärkemessausgang (426O) zu erzeugen;

eine Steuerschaltung (404), umfassend:

einen oder mehrere Stromstärkemesseingänge (434I), die kommunikativ mit dem einen oder den mehreren Stromstärkemessausgängen (426O) der einen oder mehreren Stromstärkemessschaltungen (402) der einen oder mehreren Stromverteilungsschaltungen (244) gekoppelt sind; und
wobei die Steuerschaltung (404) für eine Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244) zu Folgendem konfiguriert ist:

Erzeugen des Verteilungsstromverbindungssteuersignals (406), das den Verteilungsstromverbindungsmodus angibt, für den Verteilungsschaltsteuereingang (424I) der Stromverteilungsschaltung (244), der den Verteilungsstromverbindungsmodus angibt;
Bestimmen, ob die gemessene Stromstärke an einem Stromstärkemesseingang (434I) von dem einen oder den mehreren Stromstärkemesseingängen (434I) der Stromverteilungsschaltung (244) einen vordefinierten Stromstärkeschwellenwert überschreitet, wenn der Verteilungsschaltkreis (408) geschlossen ist, um den Verteilungsstromeingang (422I) mit dem Verteilungsstromausgang zu koppeln; und
als Reaktion darauf, dass die gemessene Stromstärke der Stromverteilungsschaltung (244) den vordefinierten Stromstärkeschwellenwert überschreitet, Übermitteln des Verteilungsstromverbindungssteuersignals (406), das den Verteilungsstromverbindungsmodus angibt, an den Verteilungsschaltsteuereingang (424I) der Stromverteilungsschaltung (244), der den Verteilungsstromunterbrechungszustand angibt, und

ein Gehäuse, das die Steuerschaltung (404), die Stromstärkemessschaltung (402) und die Stromquelle (44) enthält, **dadurch gekennzeichnet, dass** die Steuerschaltung (404) ferner zu Folgendem konfiguriert ist:

Senken eines Spannungspegel an dem Verteilungsstromausgang (403; 422O) von einem ersten Spannungspegel auf einen zweiten Spannungspegel durch Verteilen des empfangenen Stroms über den Stromleiter (246), der mit der zugewiesenen entfernten Einheit (218) gekoppelt ist;
Anheben des Spannungspegel an dem Verteilungsstromausgang (403; 422O) von dem zweiten Spannungspegel auf den ersten Spannungspegel durch Verteilen des empfangenen Stroms über den Stromleiter (246), der mit der zugewiesenen entfernten Einheit (218) gekoppelt ist;
Bestimmen, ob die gemessene Stromstärke an dem Stromstärkemesseingang (434I) von dem einen oder den mehreren Stromstärkemesseingängen (434I) der Stromverteilungsschaltung (244) den vordefinierten Stromstärkeschwellenwert überschreitet, wenn der Verteilungsschaltkreis (408) geschlossen ist, um den Verteilungsstromeingang (422I) als Reaktion auf das Anheben des Spannungspegels an dem Stromverteilungsausgang mit dem Verteilungsstromausgang (403; 422O) zu koppeln.

2. Stromverteilungssystem nach Anspruch 1, wobei: die eine oder die mehreren Stromverteilungsschaltungen (244) jeweils ferner Folgendes umfassen:

einen Verteilungsmanagementkommunikationsausgang (432O), der mit einem Managementkommunikation-Link (410) gekoppelt ist, der mit der zugewiesenen entfernten Einheit (218) von der Vielzahl von entfernten Einheiten (218) gekoppelt ist; und wobei die Steuerschaltung (404) für eine Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244) ferner zu Folgendem dazu konfiguriert ist: Übermitteln eines entfernten Stromverbindungssignal (412), umfassend einen entfernten

Stromverbindungsmodus, der einen entfernten Stromunterbrechungszustand angibt, über den Verteilungsmanagementkommunikationsausgang (432O), der mit der zugewiesenen entfernten Einheit (218) gekoppelt ist, an die Stromverteilungsschaltung (244), um zu bewirken, dass die zugewiesene entfernte Einheit (218) Stromstärke von dem Stromleiter (246) der Stromverteilungsschaltung (244) entkoppelt.

3. Stromverteilungssystem nach Anspruch 2, als Reaktion darauf, dass die gemessene Stromstärke der Stromverteilungsschaltung (244) den vordefinierten Stromstärkeschwellenwert nicht überschreitet, Übermitteln des Verteilungsstromverbindungssteuersignal (406), umfassend den Verteilungsstromverbindungsmodus, an den Verteilungsschaltsteuer Eingang (424I) der Stromverteilungsschaltung (244), der den Verteilungsstromverbindungszustand angibt.
4. Stromverteilungssystem nach Anspruch 2, wobei die Steuerschaltung (404) für die Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244) ferner zu Folgendem konfiguriert ist, Übermitteln des entfernten Stromverbindungssignals (412), umfassend den entfernten Stromverbindungsmodus, der den entfernten Stromunterbrechungszustand über den Verteilungsmanagementkommunikationsausgang (432O) angibt, bevor bestimmt wird, ob die gemessene Stromstärke an einem Stromstärkemesseingang (434I) von dem einen oder den mehreren Stromstärkemesseingängen (434I) der Stromverteilungsschaltung (244) den vordefinierten Stromstärkeschwellenwert überschreitet.
5. Stromverteilungssystem nach Anspruch 2, wobei die Steuerschaltung (404) für die Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244) ferner zu Folgendem konfiguriert ist: Übermitteln des entfernten Stromverbindungssignal (412), umfassend den entfernten Stromverbindungsmodus, der einen entfernten Stromverbindungszustand angibt, über den Verteilungsmanagementkommunikationsausgang (432O), der mit der zugewiesenen entfernten Einheit (218) gekoppelt ist, an die Stromverteilungsschaltung (244), um zu bewirken, dass die zugewiesene entfernte Einheit (218) mit einem Stromleiter (246) der Stromverteilungsschaltung (244) koppelt.
6. Stromverteilungssystem nach Anspruch 5, wobei die Steuerschaltung (404) für die Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244) zu Folgendem

konfiguriert ist:

Übermitteln des entfernten Stromverbindungssignal (412), umfassend den entfernten Stromverbindungsmodus, der den entfernten Stromverbindungs-
zustand angibt, nachdem eine vordefinierte Zeit nach Übermitteln des entfernten Stromverbindungssignals (412), umfassend den entfernten Stromverbindungsmodus, der den entfernten Stromunterbrechungszustand angibt, verstrichen ist.

7. Stromverteilungssystem nach Anspruch 5, wobei die Steuerschaltung (404) für die Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244) zu Folgendem konfiguriert ist:

Übermitteln des entfernten Stromverbindungssignal (412), umfassend den entfernten Stromverbindungsmodus, der den entfernten Stromverbindungs-
zustand angibt, vor Übermitteln des entfernten Stromverbindungssignals (412), umfassend den entfernten Stromverbindungsmodus, der den entfernten Stromunterbrechungszustand angibt.

8. Stromverteilungssystem nach Anspruch 6, wobei die Steuerschaltung (404) für die Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244) konfiguriert ist, um wiederholt:

das entfernte Stromverbindungssignal (412), umfassend den entfernten Stromverbindungsmodus, der den Zustand der entfernte Stromunterbrechung angibt, über den Verteilungsmanagementkommunikationsausgang (432O) zu übermitteln; und

das entfernte Stromverbindungssignal (412), umfassend den entfernten Stromverbindungsmodus, der den entfernten Stromverbindungs-
zustand angibt, über den Verteilungsmanagementkommunikationsausgang (432O) zu übermitteln, nachdem die vordefinierte Zeit nach Übermitteln des entfernten Stromverbindungssignals (412), umfassend den entfernten Stromverbindungsmodus, der den entfernten Stromunterbrechungszustand angibt, verstrichen ist.

9. Stromverteilungssystem nach Anspruch 1, wobei für jede Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244):

der Verteilungsstromausgang (403: 422O) den Verteilungsmanagementkommunikationsausgang (432O) umfasst; und
ferner umfassend eine Multiplexschaltung, die zwischen dem Verteilungsschaltkreis (408) und

dem Verteilungsstromausgang (403: 422O) gekoppelt ist;

wobei die Multiplexschaltung konfiguriert ist, um das Verteilungsstromverbindungssteuersignal (406) und das entfernte Stromverbindungssignal (412) über den Verteilungsstromausgang (403: 422O) an die zugewiesene entfernte Einheit (218) zu multiplexen.

10. Stromverteilungssystem nach Anspruch 2, wobei für jede Stromverteilungsschaltung (244) von dem einen oder der mehreren Stromverteilungsschaltungen (244):

der Verteilungsstromausgang (403: 422O) den Verteilungsmanagementkommunikationsausgang (432O) umfasst; und
ferner umfassend eine Kombinationsschaltung, die zwischen den Verteilungsschaltkreis (408) und den Verteilungsstromausgang (403: 422O) gekoppelt ist;

wobei die Kombinationsschaltung konfiguriert ist, um das Verteilungsstromverbindungssteuersignal (406) und das entfernte Stromverbindungssignal (412) über den Verteilungsstromausgang (403: 422O) an die zugewiesene entfernte Einheit (218) zu kombinieren.

11. Stromverteilungssystem nach Anspruch 1, wobei: jeder Stromverteilungsschaltung (244) der einen oder der mehreren Stromverteilungsschaltungen (244) ferner Folgendes umfasst:

eine zweite Stromstärkemessschaltung (402), die mit der Stromstärkemessschaltung (402) gekoppelt ist und einen zweiten Stromstärkemessausgang (426O) umfasst;
wobei die zweite Stromstärkemessschaltung (402) konfiguriert ist, um den Strom an dem Verteilungsstromausgang (403: 422O) zu messen und basierend auf der gemessenen Stromstärke an dem Verteilungsstromausgang (403: 422O) eine zweite Stromstärkemessung (428) an dem zweiten Stromstärkemessausgang (426O) zu erzeugen;
die Steuerschaltung (404) ferner umfassend:

einen oder mehrere zweite Stromstärkemessgänge (434I), die kommunikativ mit dem einen oder den mehreren zweiten Stromstärkemessausgängen (426O) der einen oder mehreren zweiten Stromstärkemessschaltungen (402) der einen oder mehreren Stromverteilungsschaltungen (244) gekoppelt sind; und
wobei die Steuerschaltung (404) für eine Stromverteilungsschaltung (244) von der einen oder den mehreren Stromvertei-

- lungsschaltungen (244) ferner zu Folgendem dazu konfiguriert ist: Bestimmen, ob die gemessene Stromstärke an einem zweiten Stromstärkemesseingang (434I) von dem einen oder den mehreren zweiten Stromstärkemesseingängen (434I) der Stromverteilungsschaltung (244) einen vordefinierten Stromstärkeschwellenwert überschreitet; und
als Reaktion darauf, dass die zweite gemessene Stromstärke der Stromverteilungsschaltung (244) den vordefinierten Stromstärkeschwellenwert überschreitet, Übermitteln des Verteilungsstromverbindungssteuersignal (406), umfassend den Verteilungsstromverbindungsmodus, an den Verteilungsschaltsteuereingang (424I) der Stromverteilungsschaltung (244), der den Verteilungsstromunterbrechungszustand angibt.
- 12.** Stromverteilungssystem nach Anspruch 1, wobei: jeder Stromverteilungsschaltung (244) der einen oder der mehreren Stromverteilungsschaltungen (244) ferner Folgendes umfasst:
- eine zweite Stromstärkemessschaltung (402), die mit der Stromstärkemessschaltung (402) gekoppelt ist und einen zweiten Stromstärkemessausgang (426O) umfasst;
wobei die zweite Stromstärkemessschaltung (402) konfiguriert ist, um den Strom an dem Verteilungsstromausgang (403: 422O) zu messen und basierend auf der gemessenen Stromstärke, die an dem Verteilungsstromausgang (403: 422O) empfangen wird, eine zweite Stromstärkemessung (428) an dem zweiten Stromstärkemessausgang (426O) zu erzeugen;
die Steuerschaltung (404) ferner umfassend:
- einen oder mehrere zweite Stromstärkemesseingänge (434I), die kommunikativ mit dem einen oder den mehreren zweiten Stromstärkemessausgängen (426O) der einen oder mehreren zweiten Stromstärkemessschaltungen (402) der einen oder mehreren Stromverteilungsschaltungen (244) gekoppelt sind; und
wobei die Steuerschaltung (404) für eine Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244) ferner zu Folgendem dazu konfiguriert ist: Bestimmen, ob die gemessene Stromstärke an einem zweiten Stromstärkemesseingang (434I) von dem einen oder den mehreren zweiten Stromstärkemesseingängen (434I) der Stromverteilungsschaltung (244) einen vordefinierten Stromstärkeschwellenwert überschreitet; und
als Reaktion darauf, dass die zweite gemessene Stromstärke der Stromverteilungsschaltung (244) den vordefinierten Stromstärkeschwellenwert überschreitet, Übermitteln des Verteilungsstromverbindungssteuersignal (406), umfassend den Verteilungsstromverbindungsmodus, an den Verteilungsschaltsteuereingang (424I) der Stromverteilungsschaltung (244), der den Verteilungsstromunterbrechungszustand angibt.
- 13.** Stromverteilungssystem nach Anspruch 1, wobei: jeder Stromverteilungsschaltung (244) der einen oder der mehreren Stromverteilungsschaltungen (244) ferner Folgendes umfasst:
- eine zweite Stromstärkemessschaltung (402), umfassend einen zweiten Stromstärkemessausgang (426O);
wobei die zweite Stromstärkemessschaltung (402) konfiguriert ist, um den Strom an einem zweiten Verteilungsstromausgang (403: 422O) zu messen und basierend auf der gemessenen Stromstärke, die an dem zweiten Verteilungsstromausgang (403: 422O) empfangen wird, eine zweite Stromstärkemessung (428) an dem zweiten Stromstärkemessausgang (426O) zu erzeugen;
die Steuerschaltung (404) ferner umfassend:
- einen oder mehrere zweite Stromstärkemesseingänge (434I), die kommunikativ mit dem einen oder den mehreren zweiten Stromstärkemessausgängen (426O) der einen oder mehreren zweiten Stromstärkemessschaltungen (402) der einen oder mehreren Stromverteilungsschaltungen (244) gekoppelt sind; und
wobei die Steuerschaltung (404) für eine Stromverteilungsschaltung (244) von der einen oder den mehreren Stromverteilungsschaltungen (244) ferner zu Folgendem dazu konfiguriert ist: Bestimmen einer gemessenen Differenzstromstärke zwischen der gemessenen Stromstärke an dem Stromstärkemesseingang (434I) und der zweiten gemessenen Stromstärke an dem zweiten Stromstärkemesseingang (434I);
Bestimmen, ob die gemessene Differenzstromstärke den vordefinierten Stromstärkeschwellenwert überschreitet; und
als Reaktion darauf, dass die gemessene Differenzstromstärke der Stromverteilungsschaltung (244) den vordefinierten

- Stromstärkeschwellenwert überschreitet, Übermitteln des Verteilungsstromverbindungssteuersignal (406), umfassend den Verteilungsstromverbindungsmodus, an den Verteilungsschaltsteuereingang (424I) der Stromverteilungsschaltung (244), der den Verteilungsstromunterbrechungszustand angibt.
14. Stromverteilungssystem nach Anspruch 1, wobei die Steuerschaltung (404) ferner konfiguriert ist, um periodisch ein Überwachungssignal zu erzeugen; und ferner umfassend eine Überwachungssteuerung, die zu Folgendem konfiguriert ist:

Empfangen des Überwachungssignals; als Reaktion darauf, dass das Überwachungssignal nicht innerhalb einer vordefinierten Zeitspanne empfangen wird, bewirken, dass das Verteilungsstromverbindungssteuersignal (406) den Verteilungsstromunterbrechungszustand anzugeben.

Revendications

1. Système de distribution d'électricité comprenant : un ou plusieurs circuits de distribution d'électricité (244) comprenant chacun :
- une entrée d'électricité de distribution (422I) configurée pour recevoir un courant distribué par une alimentation électrique (400) ;
 - une sortie d'électricité de distribution configurée pour distribuer le courant reçu sur un conducteur électrique (246) couplé à une unité distante attribuée (218) parmi une pluralité d'unités distantes (218) ;
 - un circuit commutateur de distribution (408) couplé entre l'entrée d'électricité de distribution (422I) et la sortie d'électricité de distribution, le circuit commutateur de distribution (408) comprenant une entrée de commande de commutateur de distribution (424I) configurée pour recevoir un signal de commande de connexion électrique de distribution (406) indiquant un mode de connexion électrique de distribution ;
 - le circuit commutateur de distribution (408) configuré pour être fermé pour coupler l'entrée d'électricité de distribution (422I) à la sortie d'électricité de distribution en réponse au mode de connexion électrique de distribution indiquant un état de connexion électrique de distribution ; et
 - le circuit commutateur de distribution (408) configuré en outre pour être ouvert pour découpler l'entrée d'électricité de distribution (422I) de la sortie d'électricité de distribution en réponse au

mode de connexion électrique de distribution indiquant un état de déconnexion électrique de distribution ; et

un circuit de mesure de courant (402) couplé à la sortie d'électricité de distribution et comprenant une sortie de mesure de courant (426O) ; le circuit de mesure de courant (402) configuré pour mesurer un courant au niveau de la sortie d'électricité de distribution et générer une mesure de courant sur la sortie de mesure de courant (426O) sur la base du courant mesuré au niveau de la sortie d'électricité de distribution ; un circuit (404) de dispositif de commande comprenant :

une ou plusieurs entrées de mesure de courant (434I) couplées de manière communicative à la ou aux sorties de mesure de courant (426O) du ou des circuits de mesure de courant (402) du ou des circuits de distribution d'électricité (244) ; et

le circuit (404) de dispositif de commande configuré, pour un circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour :

générer le signal de commande de connexion électrique de distribution (406) indiquant le mode de connexion électrique de distribution à l'entrée de commande de commutateur de distribution (424I) du circuit de distribution d'électricité (244) indiquant l'état de connexion électrique de distribution ;

déterminer si le courant mesuré sur une entrée de mesure de courant (434I) parmi la ou les entrées de mesure de courant (434I) du circuit de distribution d'électricité (244) dépasse un niveau de courant seuil prédéfini lorsque le circuit commutateur de distribution (408) est fermé pour coupler l'entrée d'électricité de distribution (422I) à la sortie d'électricité de distribution ; et

en réponse au courant mesuré du circuit de distribution d'électricité (244) dépassant le niveau de courant seuil prédéfini, communiquer le signal de commande de connexion électrique de distribution (406) indiquant le mode de connexion électrique de distribution à l'entrée de commande de commutateur de distribution (424I) du circuit de distribution d'électricité (244) indiquant l'état de déconnexion électrique de distribution, et

un boîtier contenant le circuit (404) de dispositif de commande, le circuit de

mesure de courant (402) et l'alimentation électrique (44), **caractérisé en ce que**

le circuit (404) de dispositif de commande est en outre configuré pour :

abaisser un niveau de tension d'un premier niveau de tension à un second niveau de tension sur la sortie d'électricité de distribution (403 : 422O) distribuant le courant reçu sur le conducteur électrique (246) couplé à l'unité distante attribuée (218) ;
augmenter le niveau de tension du second niveau de tension au premier niveau de tension sur la sortie d'électricité de distribution (403 : 422O) distribuant le courant reçu sur le conducteur électrique (246) couplé à l'unité distante attribuée (218) ;
déterminer si le courant mesuré sur l'entrée de mesure de courant (434I) parmi la ou les entrées de mesure de courant (434I) du circuit de distribution d'électricité (244) dépasse le niveau de courant seuil prédéfini lorsque le circuit commutateur de distribution (408) est fermé pour coupler l'entrée d'électricité de distribution (422I) à la sortie d'électricité de distribution (403 : 422O) en réponse à l'augmentation du niveau de tension sur la sortie de distribution d'électricité.

2. Système de distribution d'électricité selon la revendication 1, ledit ou lesdits circuits de distribution d'électricité (244) comprenant chacun en outre :

une sortie de communications de gestion de distribution (432O) couplée à une liaison de communications de gestion (410) couplée à l'unité distante attribuée (218) parmi la pluralité d'unités distantes (218) ; et
ledit circuit (404) de dispositif de commande étant en outre configuré, pour un circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour :
communiquer un signal de connexion électrique à distance (412) comprenant un mode de connexion électrique à distance indiquant un état de déconnexion électrique à distance sur la sortie de communication de gestion de distribution (432O) couplée à l'unité distante attribuée (218) au circuit de distribution d'électricité (244) pour

amener l'unité distante attribuée (218) à découpler le courant du conducteur électrique (246) du circuit de distribution d'électricité (244).

3. Système de distribution d'électricité selon la revendication 2, en réponse au courant mesuré du circuit de distribution d'électricité (244) ne dépassant pas le niveau de courant seuil prédéfini, communiquer le signal de commande de connexion électrique de distribution (406) comprenant le mode de connexion électrique de distribution à l'entrée de commande de commutateur de distribution (424I) du circuit de distribution d'électricité (244) indiquant l'état de connexion électrique de distribution.
4. Système de distribution d'électricité selon la revendication 2, ledit circuit (404) de dispositif de commande étant en outre configuré, pour le circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour
communiquer le signal de connexion électrique à distance (412) comprenant le mode de connexion électrique à distance indiquant l'état de déconnexion électrique à distance sur la sortie de communication de gestion de distribution (432O) avant de déterminer si le courant mesuré sur une entrée de mesure de courant (434I) parmi le ou les entrées de mesure de courants (434I) du circuit de distribution d'électricité (244) dépasse le niveau de courant seuil prédéfini.
5. Système de distribution d'électricité selon la revendication 2, ledit circuit (404) de dispositif de commande étant en outre configuré, pour le circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour :
communiquer le signal de connexion électrique à distance (412) comprenant le mode de connexion électrique à distance indiquant un état de connexion électrique à distance sur la sortie de communication de gestion de distribution (432O) couplée à l'unité distante attribuée (218) au circuit de distribution d'électricité (244) pour amener l'unité distante attribuée (218) à se coupler à un conducteur électrique (246) du circuit de distribution d'électricité (244).
6. Système de distribution d'électricité selon la revendication 5, ledit circuit (404) de dispositif de commande étant configuré, pour le circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour :
communiquer le signal de connexion électrique à distance (412) comprenant le mode de connexion électrique à distance indiquant l'état de connexion électrique à distance après qu'un temps prédéfini s'est écoulé après la communication du signal de connexion électrique à distance (412) comprenant le mode de connexion électrique à distance indi-

quant l'état de déconnexion électrique à distance.

7. Système de distribution d'électricité selon la revendication 5, ledit circuit (404) de dispositif de commande étant

configuré, pour le circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour :

communiquer le signal de connexion électrique à distance (412) comprenant le mode de connexion électrique à distance indiquant l'état de connexion électrique à distance avant de communiquer le signal de connexion électrique à distance (412) comprenant le mode de connexion électrique à distance indiquant l'état de déconnexion électrique à distance.

8. Système de distribution d'électricité selon la revendication 6, ledit circuit (404) de dispositif de commande étant configuré, pour le circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour, à plusieurs reprises :

communiquer le signal de connexion électrique à distance (412) comprenant le mode de connexion électrique à distance indiquant l'état de déconnexion électrique à distance sur la sortie de communication de gestion de distribution (432O) ; et

communiquer le signal de connexion électrique à distance (412) comprenant le mode de connexion électrique à distance indiquant l'état de connexion électrique à distance sur la sortie de communication de gestion de distribution (432O) après que le temps prédéfini s'est écoulé après la communication du signal de connexion électrique à distance (412) comprenant le mode de connexion électrique à distance indiquant l'état de déconnexion électrique à distance.

9. Système de distribution d'électricité selon la revendication 1, pour chaque circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244) :

ladite sortie d'électricité de distribution (403 : 422O) comprenant la sortie de communications de gestion de distribution (432O) ; et comprenant en outre un circuit de multiplexage couplé entre le circuit commutateur de distribution (408) et la sortie d'électricité de distribution (403 : 422O) ; ledit circuit de multiplexage configuré pour multiplexer le signal de commande de connexion électrique de distribution (406) et le signal de connexion électrique à distance (412) sur la sortie d'électricité de distribution (403 : 422O) vers l'unité distante attribuée (218).

10. Système de distribution d'électricité selon la revendication 2, pour chaque circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244) :

ladite sortie d'électricité de distribution (403 : 422O) comprenant la sortie de communications de gestion de distribution (432O) ; et comprenant en outre un circuit de combinaison couplé entre le circuit commutateur de distribution (408) et la sortie d'électricité de distribution (403 : 422O) ; ledit circuit de combinaison configuré pour combiner le signal de commande de connexion électrique de distribution (406) et le signal de connexion électrique à distance (412) sur la sortie d'électricité de distribution (403 : 422O) vers l'unité distante attribuée (218).

11. Système de distribution d'électricité selon la revendication 1, chaque circuit de distribution d'électricité (244) du ou des circuits de distribution d'électricité (244) comprenant en outre :

un second circuit de mesure de courant (402) couplé au circuit de mesure de courant (402) et comprenant une seconde sortie de mesure de courant (426O) ; ledit second circuit de mesure de courant (402) étant configuré pour mesurer le courant au niveau de la sortie d'électricité de distribution (403 : 422O) et générer une seconde mesure de courant (428) sur la seconde sortie de mesure de courant (426O) sur la base du courant mesuré au niveau de la sortie d'électricité de distribution (403 : 422O) ; ledit circuit (404) de dispositif de commande comprenant en outre :

une ou plusieurs secondes entrées de mesure de courant (434I) couplées en communication à la ou aux secondes sorties de mesure de courant (426O) du ou des seconds circuits de mesure de courant (402) du ou des circuits de distribution d'électricité (244) ; et ledit circuit (404) de dispositif de commande configuré en outre, pour un circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour : déterminer si le courant mesuré sur une seconde entrée de mesure de courant (434I) parmi la ou les secondes entrées de mesure de courant (434I) du circuit de distribution d'électricité (244) dépasse le niveau de courant seuil prédéfini ; et en réponse au second courant mesuré du

- circuit de distribution d'électricité (244) dépassant le niveau de courant seuil prédéfini, communiquer le signal de commande de connexion électrique de distribution (406) comprenant le mode de connexion électrique de distribution à l'entrée de commande de commutateur de distribution (424I) du circuit de distribution d'électricité (244) indiquant l'état de déconnexion électrique de distribution.
- 12.** Système de distribution d'électricité selon la revendication 1, chaque circuit de distribution d'électricité (244) du ou des circuits de distribution d'électricité (244) comprenant en outre :
- un second circuit de mesure de courant (402) couplé au circuit de mesure de courant (402) et comprenant une seconde sortie de mesure de courant (426O) ;
 - ledit second circuit de mesure de courant (402) étant configuré pour mesurer le courant au niveau de la sortie d'électricité de distribution (403 : 422O) et générer une seconde mesure de courant (428) sur la seconde sortie de mesure de courant (426O) sur la base du courant mesuré reçu sur la sortie d'électricité de distribution (403 : 422O) ;
 - ledit circuit (404) de dispositif de commande comprenant en outre :
 - une ou plusieurs secondes entrées de mesure de courant (434I) couplées en communication à la ou aux secondes sorties de mesure de courant (426O) du ou des seconds circuits de mesure de courant (402) du ou des circuits de distribution d'électricité (244) ; et
 - ledit circuit (404) de dispositif de commande configuré en outre, pour un circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour : déterminer si le courant mesuré sur une seconde entrée de mesure de courant (434I) parmi la ou les secondes entrées de mesure de courant (434I) du circuit de distribution d'électricité (244) dépasse le niveau de courant seuil prédéfini ; et
 - en réponse au second courant mesuré du circuit de distribution d'électricité (244) dépassant le niveau de courant seuil prédéfini, communiquer le signal de commande de connexion électrique de distribution (406) comprenant le mode de connexion électrique de distribution à l'entrée de commande de commutateur de distribution (424I) du circuit de distribution d'électricité (244) indiquant l'état de déconnexion électrique de distribution.
- 13.** Système de distribution d'électricité selon la revendication 1, chaque circuit de distribution d'électricité (244) du ou des circuits de distribution d'électricité (244) comprenant en outre :
- un second circuit de mesure de courant (402) comprenant une seconde sortie de mesure de courant (426O) ;
 - ledit second circuit de mesure de courant (402) configuré pour mesurer le courant au niveau d'une seconde sortie d'électricité de distribution (403 : 422O) et générer une seconde mesure de courant (428) sur la seconde sortie de mesure de courant (426O) sur la base du courant mesuré reçu sur la seconde sortie d'électricité de distribution (403 : 422O) ;
 - ledit circuit (404) de dispositif de commande comprenant en outre :
 - une ou plusieurs secondes entrées de mesure de courant (434I) couplées en communication à la ou aux secondes sorties de mesure de courant (426O) du ou des seconds circuits de mesure de courant (402) du ou des circuits de distribution d'électricité (244) ; et
 - le circuit (404) de dispositif de commande étant en outre configuré, pour un circuit de distribution d'électricité (244) parmi le ou les circuits de distribution d'électricité (244), pour : déterminer un courant différentiel mesuré entre le courant mesuré sur l'entrée de mesure de courant (434I) et le second courant mesuré sur la seconde entrée de mesure de courant (434I) ;
 - déterminer si le courant différentiel mesuré dépasse le niveau de courant seuil prédéfini ; et
 - en réponse au courant différentiel mesuré du circuit de distribution d'électricité (244) dépassant le niveau de courant seuil prédéfini, communiquer le signal de commande de connexion électrique de distribution (406) comprenant le mode de connexion électrique de distribution à l'entrée de commande de commutateur de distribution (424I) du circuit de distribution d'électricité (244) indiquant l'état de déconnexion électrique de distribution.
- 14.** Système de distribution d'électricité selon la revendication 1, ledit circuit (404) de dispositif de commande étant en outre configuré pour générer périodiquement un signal de surveillance ; et

comprenant en outre un dispositif de commande de surveillance configuré pour :

recevoir le signal de surveillance ;
en réponse à la non-réception du signal de surveillance dans une période de temps prédéfinie,
amener le signal de commande de connexion électrique de distribution (406) (406) à indiquer l'état de déconnexion électrique de distribution.

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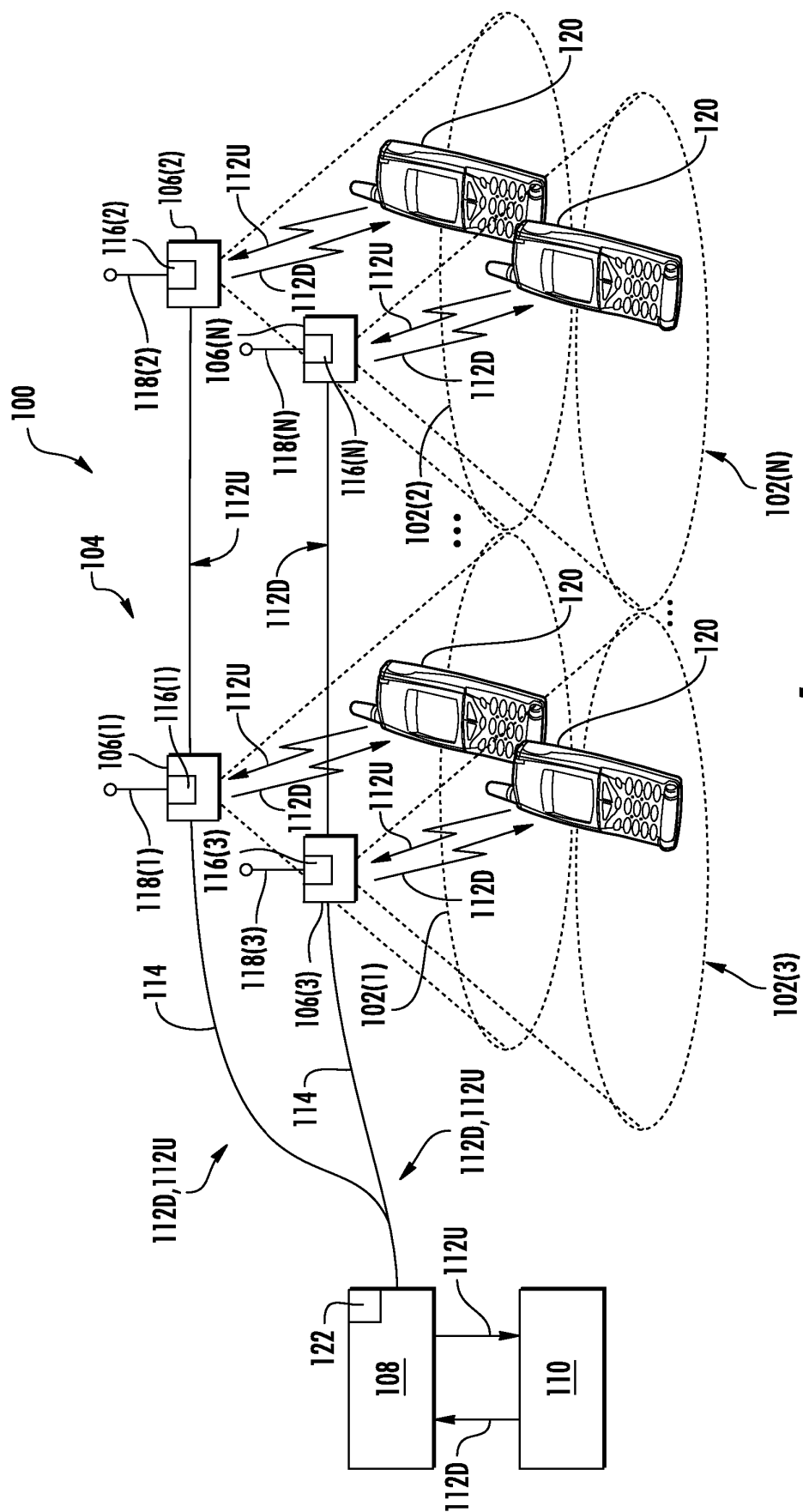


FIG. 1

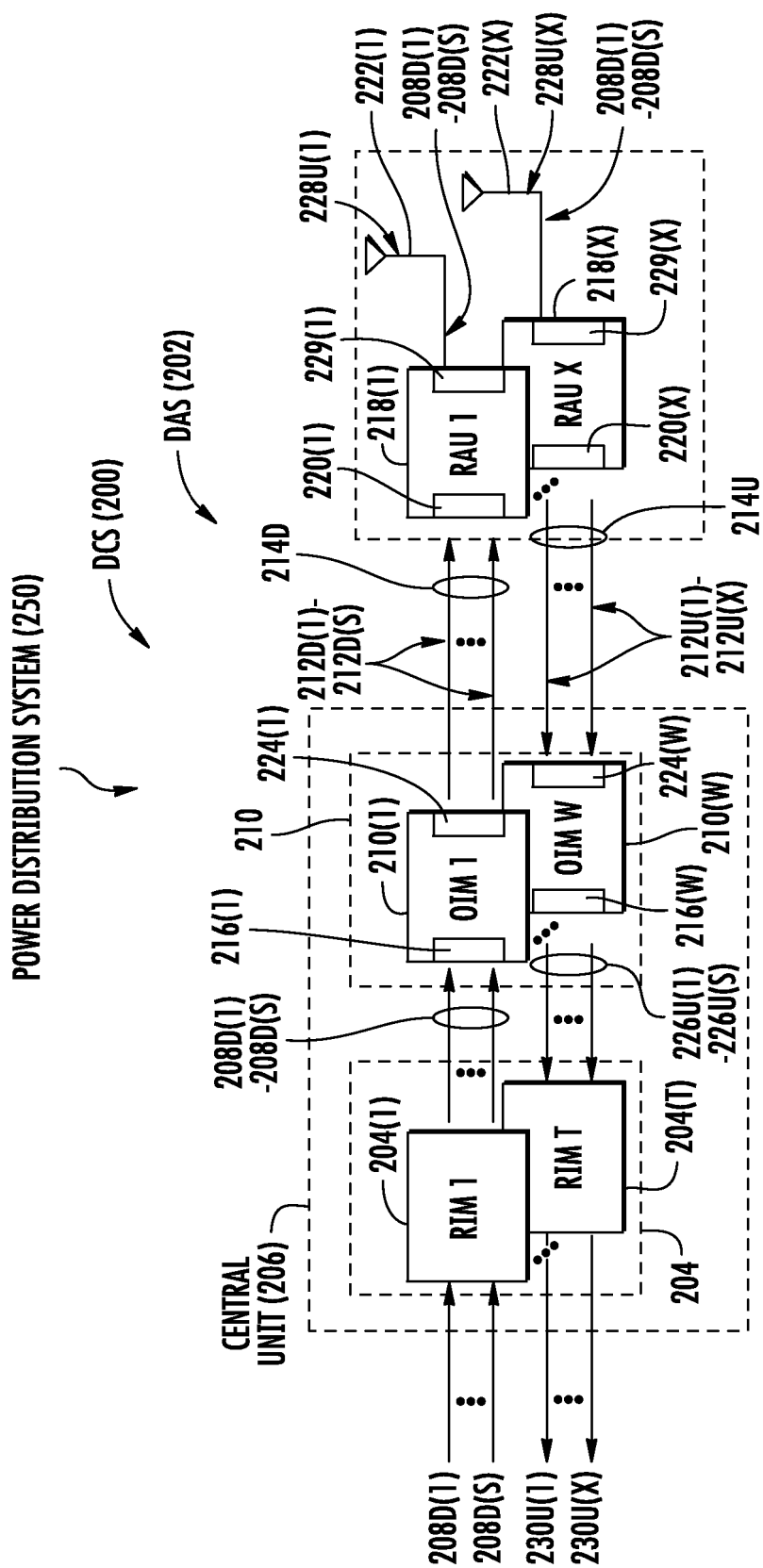


FIG. 2

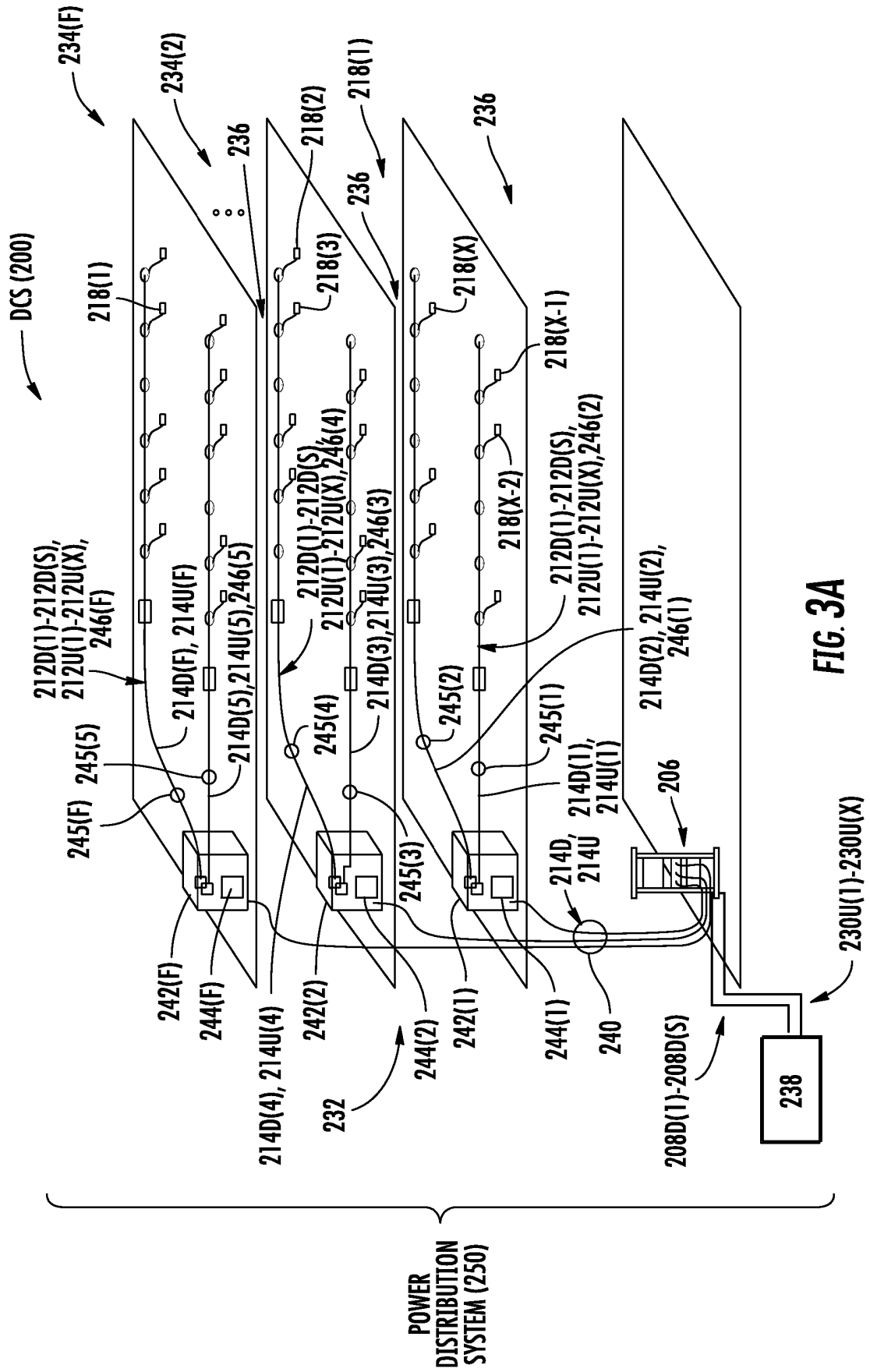


FIG. 3A

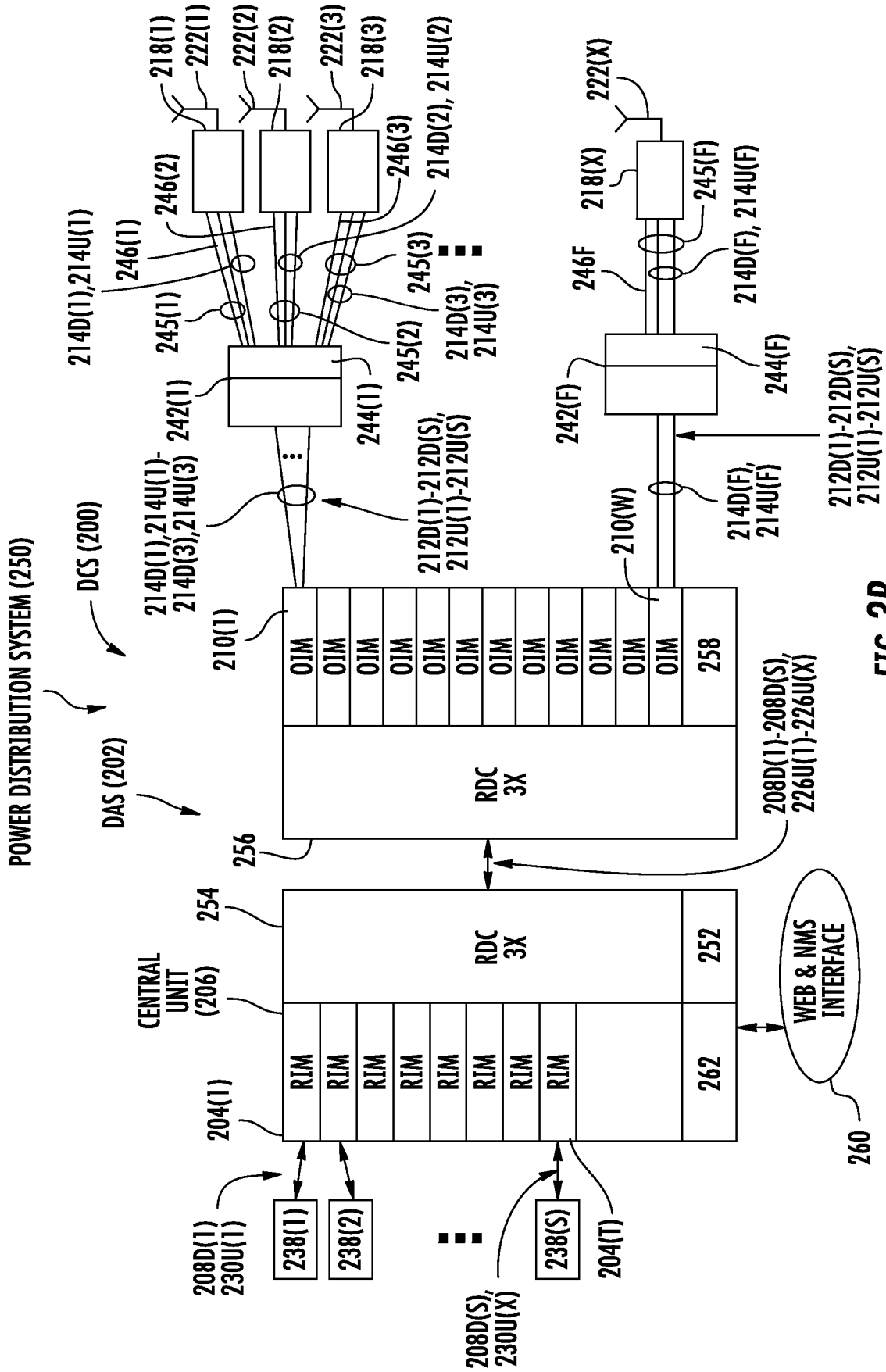
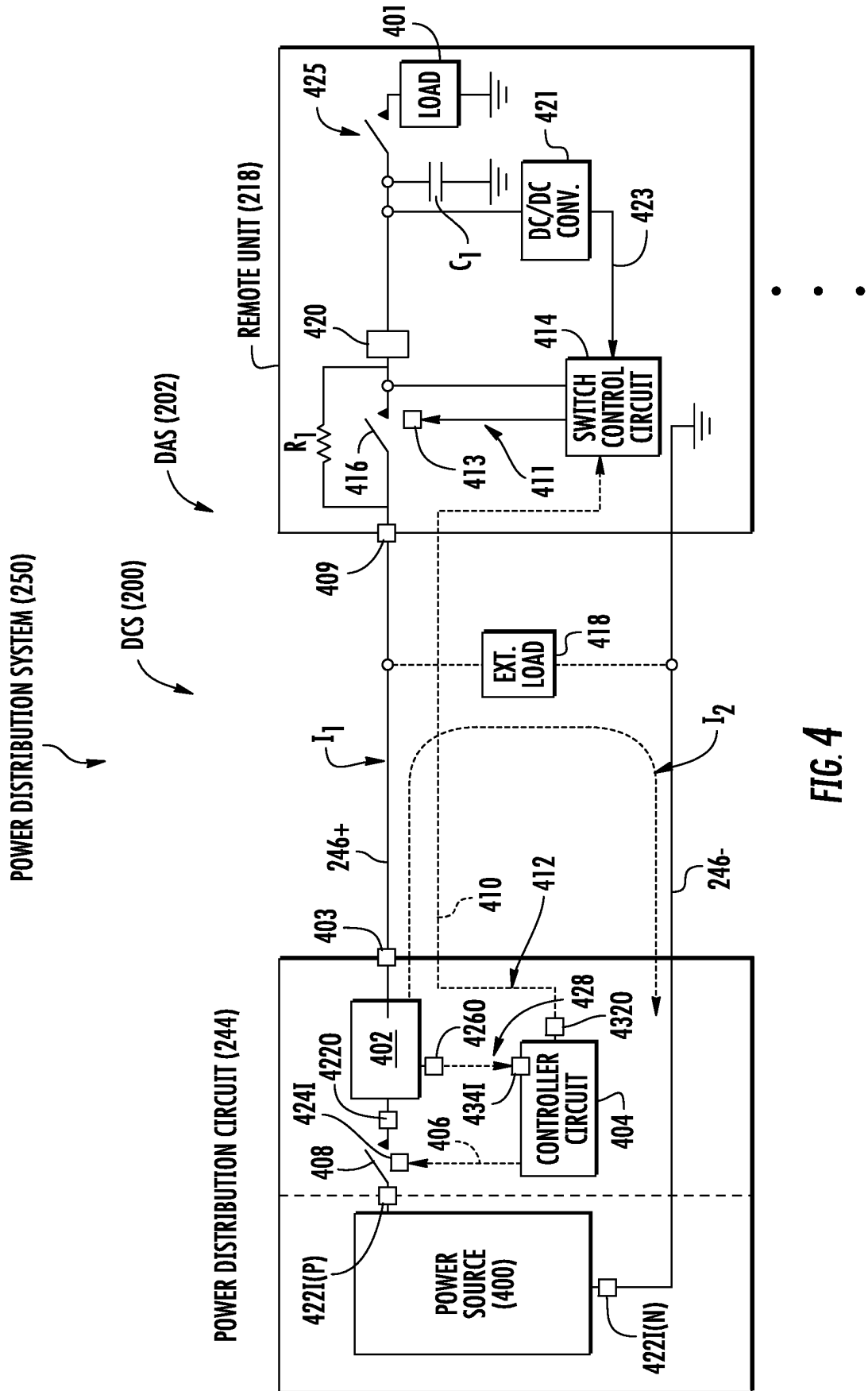
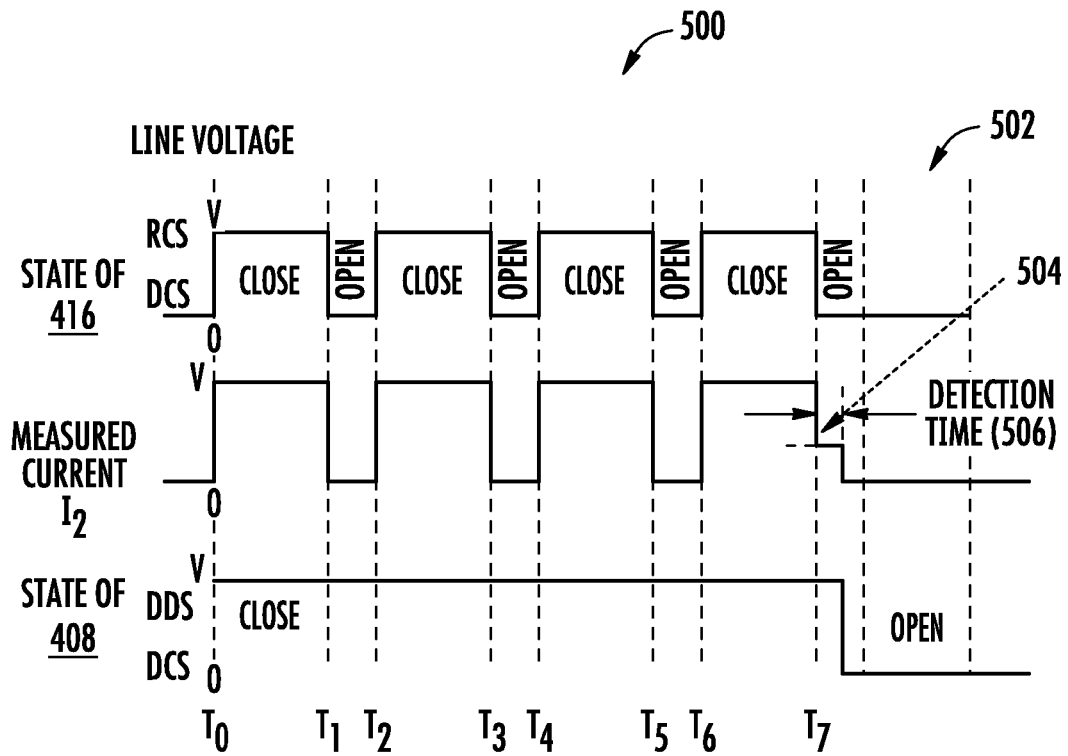


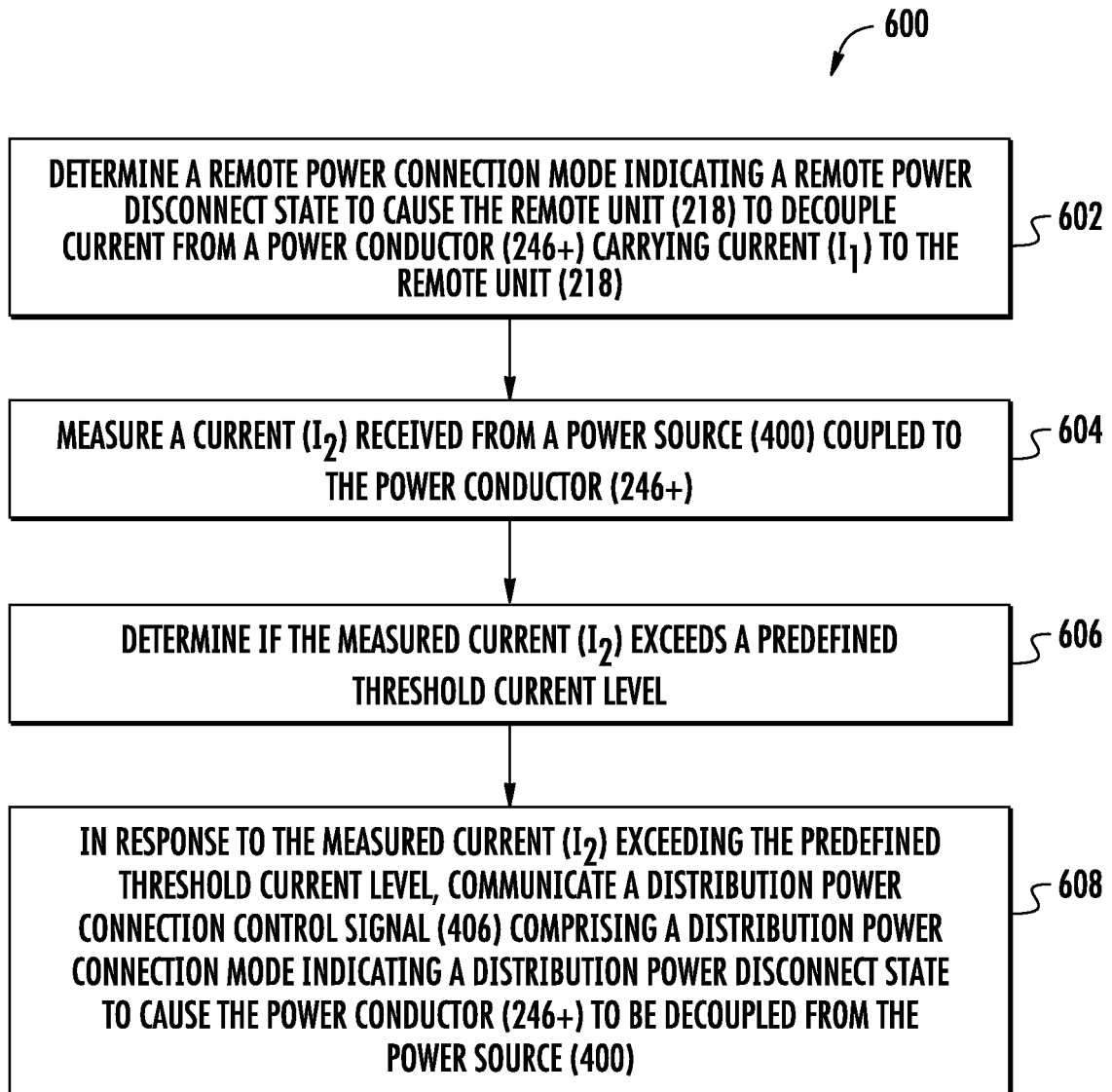
FIG. 3B





RCS- REMOTE POWER CONNECT STATE
 RDS- REMOTE POWER DISCONNECT STATE
 DCS- DISTRIBUTION POWER CONNECT STATE
 DDS- DISTRIBUTION POWER DISCONNECT STATE

FIG. 5

**FIG. 6**

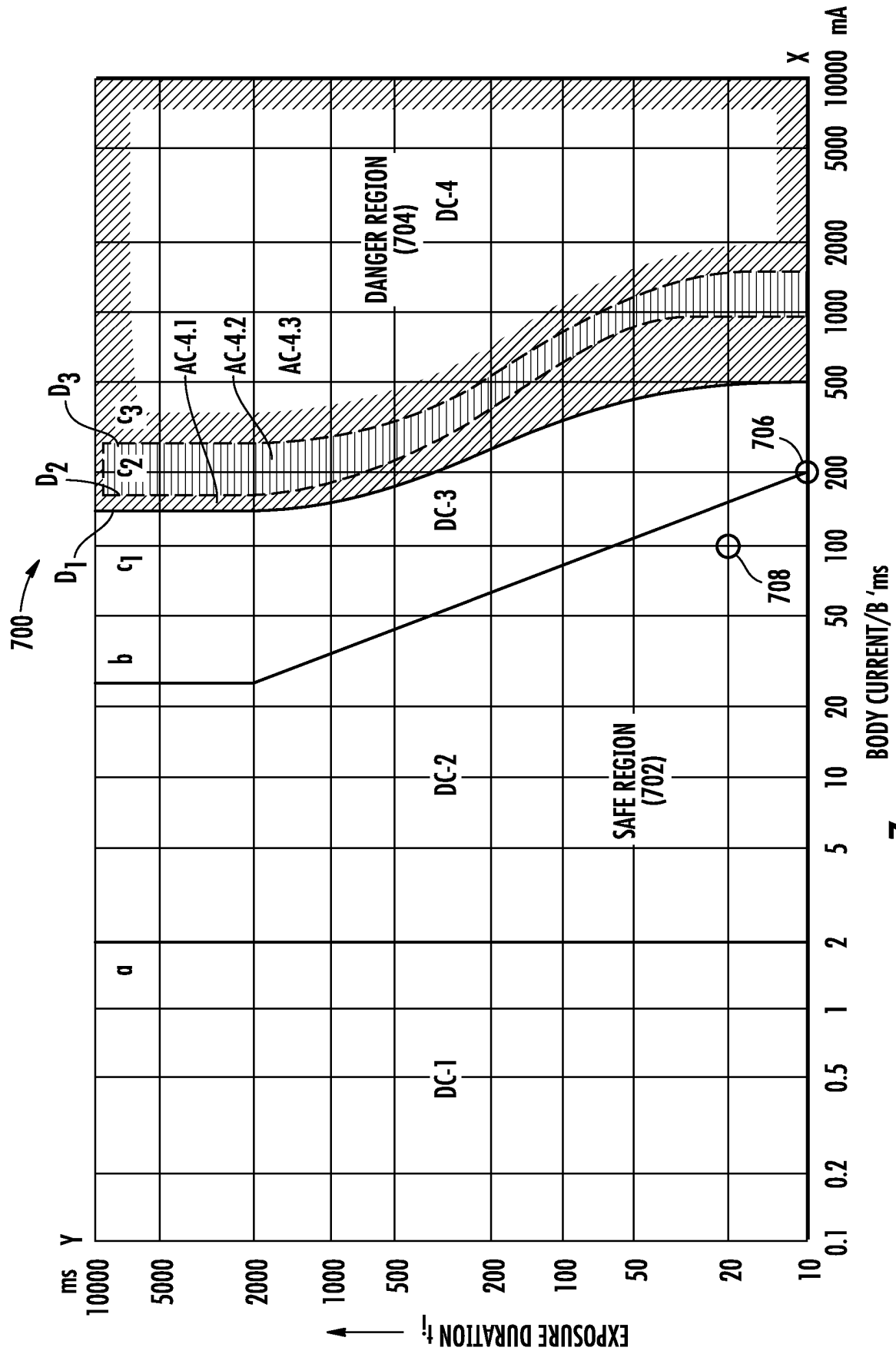


FIG. 7

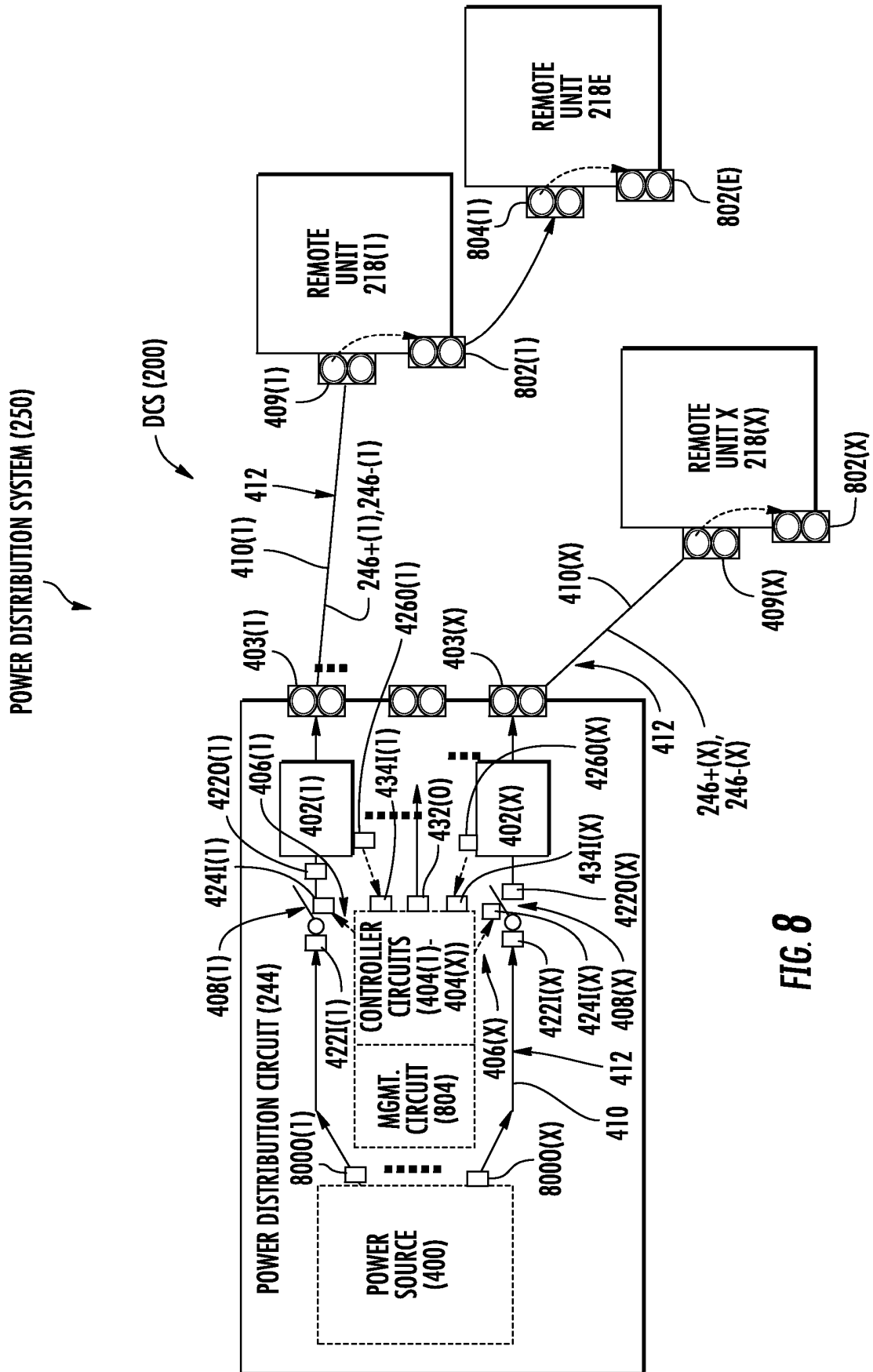


FIG. 8

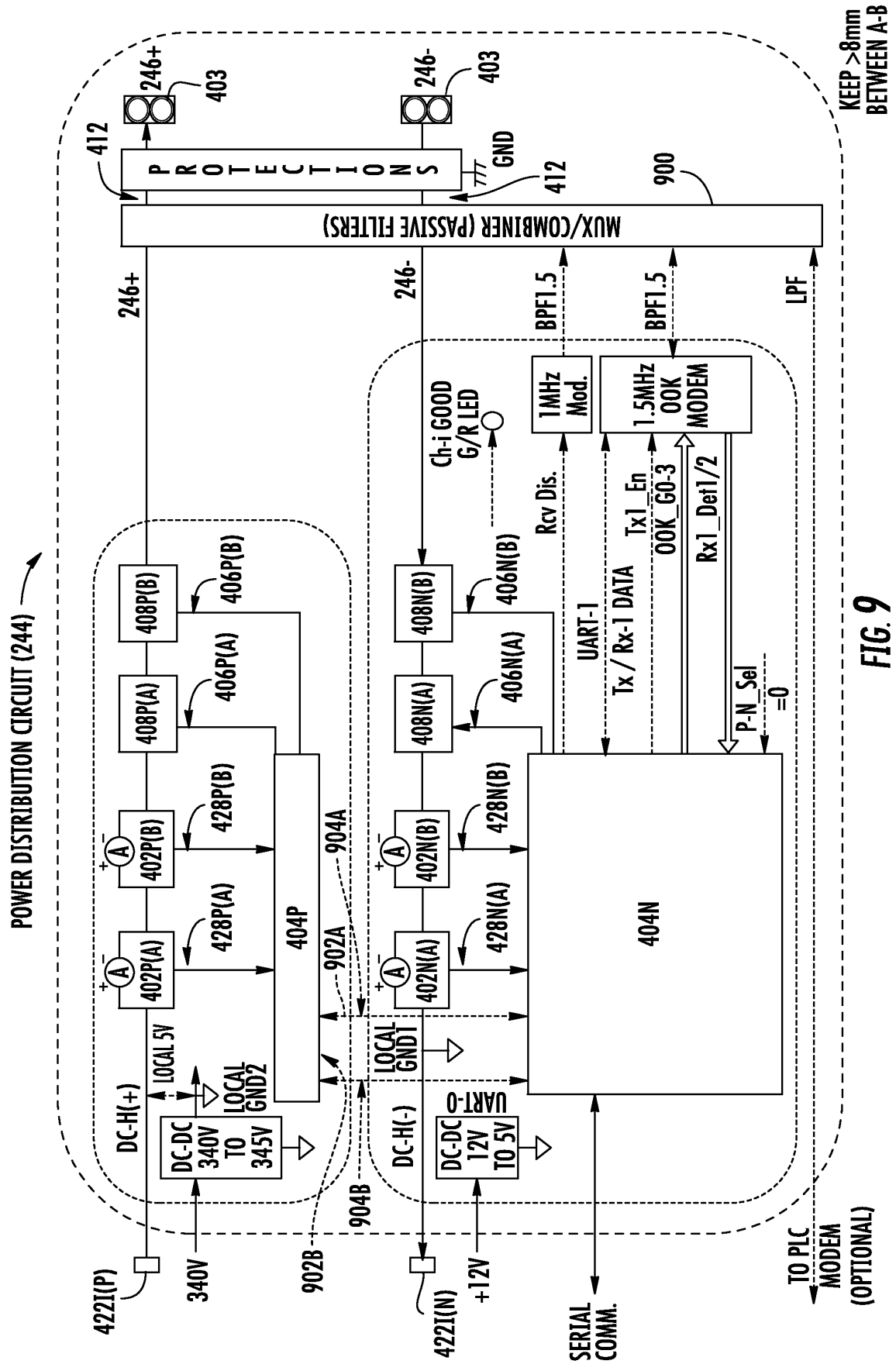


FIG. 9

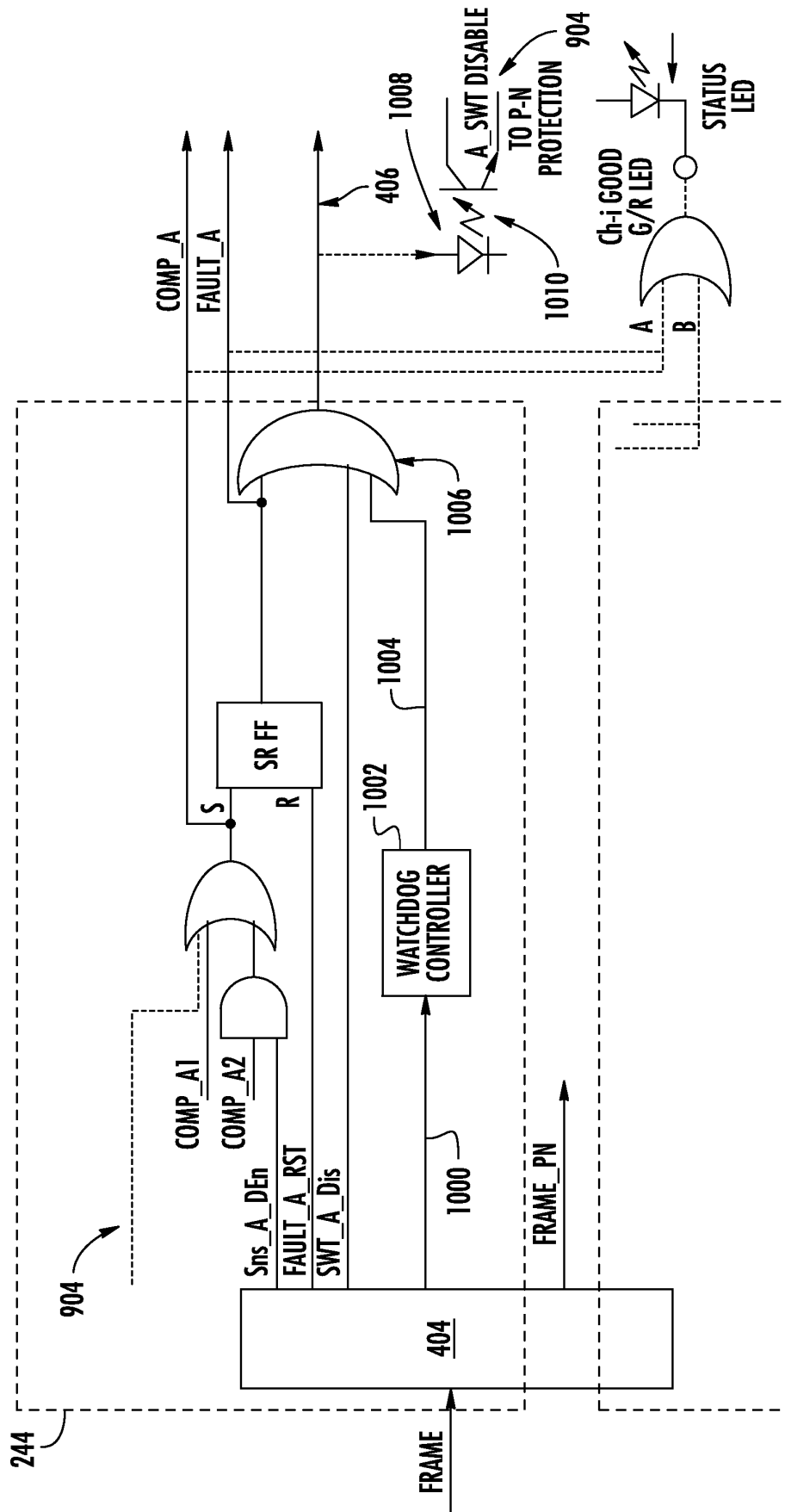


FIG. 10

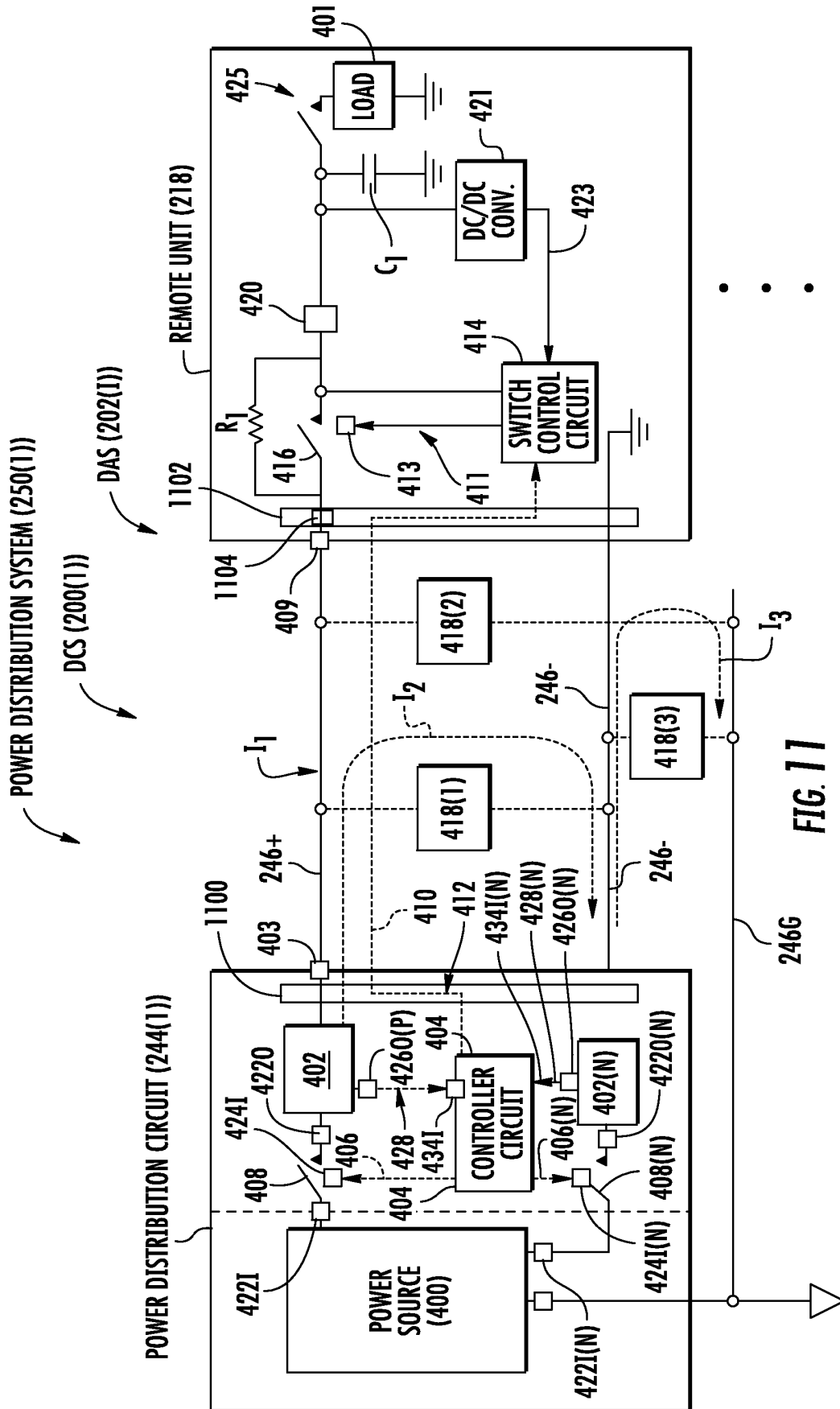


FIG. 11

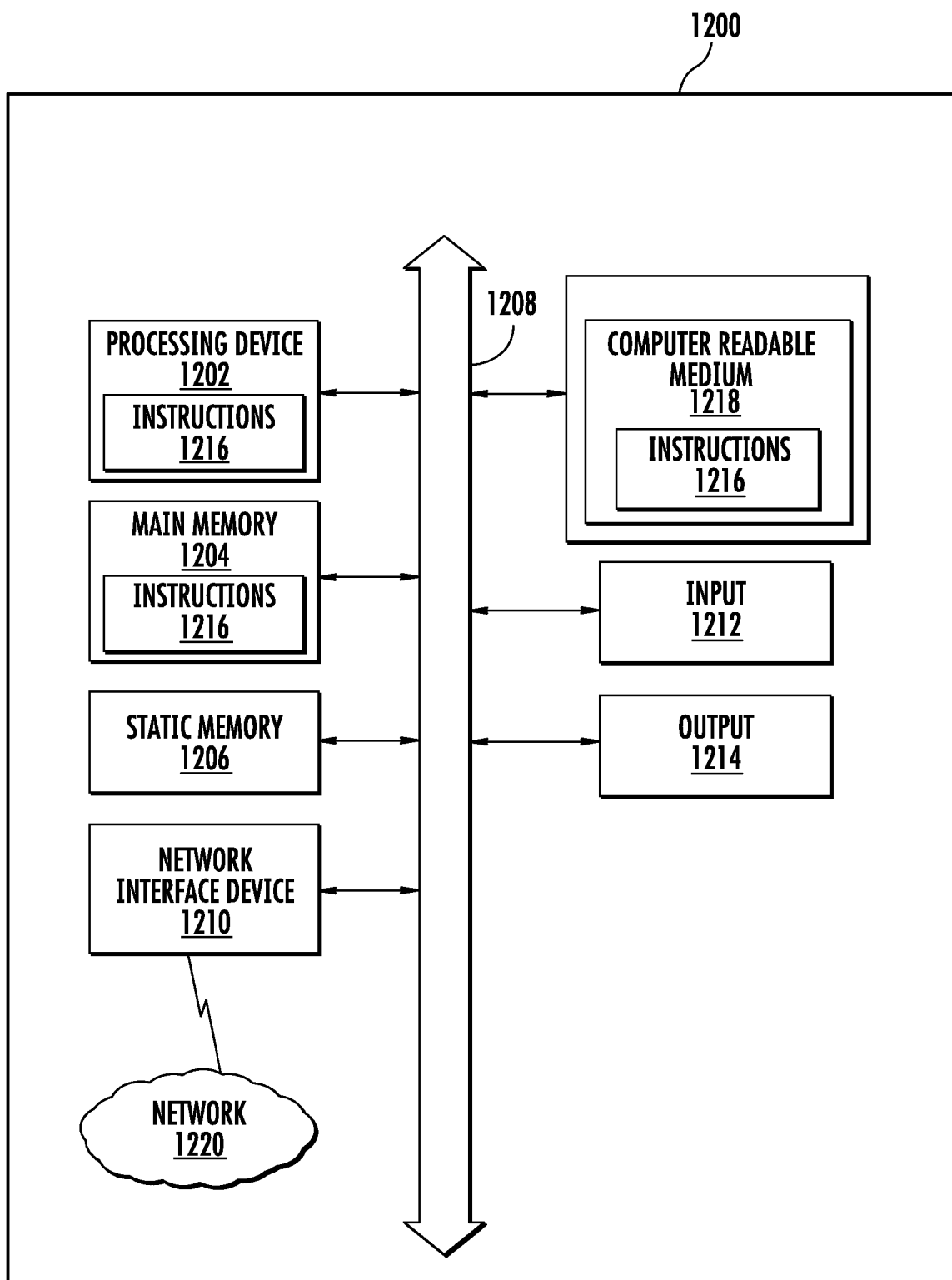


FIG. 12

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2011007443 A1 [0006]